IN THE UNITED STATES DISTRICT COURT
FOR THE WESTERN DISTRICT OF TEXAS
WACO DIVISION

Midas Green Technologies, LLC, Plaintiff, v. **Rhodium Enterprises, Inc.**; **Rhodium Technologies LLC;** **Rhodium 10MW LLC**; **Rhodium 2.0 LLC;** **Rhodium 30MW LLC**; **Rhodium Encore LLC**; **Rhodium Renewables LLC**; **Rhodium Renewables Sub LLC;** and **Rhodium Ready Ventures LLC.** Defendants.	Case No. 6:22-cv-00050-ADA

OPENING EXPERT REPORT OF ALFONSO ORTEGA, PH.D.
REGARDING INVALIDITY

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ASSIGNMENT

Description of Task

1. I have been retained as an expert in this case on behalf of Defendants Rhodium Enterprises, Inc., Rhodium Technologies LLC, Rhodium 10MW LLC, Rhodium 2.0 LLC, Rhodium 30MW LLC, Rhodium Encore LLC, Rhodium Renewables LLC, Rhodium Renewables Sub LLC, and Rhodium Ready Ventures LLC (collectively, "Rhodium") to provide expert opinions and testimony regarding U.S. Patent No. 10,405,457 (the "'457 patent") and U.S. Patent No. 10,820,446 (the "'446 patent") (collectively, the "Asserted Patents"), and regarding technology involved in this case, including prior art and the state of the art at the time of the purported invention of the Asserted Patents. I expect to testify at trial regarding the matters set forth in this report if asked about these matters by the Court or the parties' attorneys.

2. I understand that Midas Green Technologies, LLC ("MGT") is asserting claims 1, 2, 5, 6, 7, 10, 11, 14, and 15 of the '457 patent and claims 1, 2, 5, 6, 7, and 10 of the '446 patent (collectively, the "Asserted Claims").[1]

Information Considered

3. A complete list of the information I considered in forming my opinions is attached as **Exhibit A**. As part of my diligence, I have also reviewed Rhodium's Final Invalidity Contentions,[2] the Expert Report of Dr. Issam Mudawar Regarding Invalidity of the Asserted Claims and Declaration of Dr. Issam Mudawar on Disputed Claim Terms served in *Midas Green Technologies, LLC v. Immersion Systems LLC*, No. 4:20-cv-00555-O (N.D. Tex. 2020),[3] as well as the declarations of Dr. Issam Mudawar filed in *Immersion Systems LLC v. Midas Green Technologies, LLC*, No. IPR2021-01176 (P.T.A.B. June 23, 2021) and *Immersion Systems LLC v. Midas Green Technologies, LLC*, PGR2021-00104 (PTAB July 26, 2021).[4] I have repurposed some of these materials, and where I have done so I agree with those contentions and opinions and adopt them as my own for purposes of this report.

QUALIFICATIONS AND EXPERIENCE

Educational Background

4. The most recent version of my *curriculum vitae* is attached as **Exhibit B**, which describes my qualifications.

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[1] *See generally* Final Infringement Contentions.
[2] *See generally* Defendants' Final Invalidity Contentions.
[3] *See* Expert Report of Dr. Issam Mudawar Regarding Invalidity of the Asserted Claims, *Immersion Systems LLC*, No. 4:20-cv-00555-O (N.D. Tex. Feb. 7, 2022); Declaration of Dr. Issam Mudawar on Disputed Claim Terms at MIDAS0000998-1051.
[4] Exhibit 1020, Declaration of Dr. Issam Mudawar, *Immersion Systems LLC v. Midas Green Technologies, LLC*, No. IPR2021-01176 (P.T.A.B. June 23, 2021); Exhibit 1020, Declaration of Dr. Issam Mudawar, *Immersion Systems LLC v. Midas Green Technologies, LLC*, PGR2021-00104 (PTAB July 26, 2021).

5. I received a Bachelor of Science in Mechanical Engineering from The University of Texas-El Paso in 1976. In 1978, I received a Master of Science in Mechanical Engineering from Stanford University. From 1981 to 1986, I served as a research assistant in the Thermosciences Division of the Mechanical Engineering Department at Stanford University, and in 1986, I received a Ph.D. in Mechanical Engineering from Stanford University.

Career History

6. I have over forty years of experience and education in heat transfer and thermal sciences, including the cooling of electronics. I began my professional career focusing on research in solar and geothermal energy topics at Sandia National Laboratories in Albuquerque, New Mexico, where I served as a member of the technical staff from 1978 to 1981 and again from 1986 to 1988.

7. From 1988 to 2005, I was on the faculty of the Department of Aerospace and Mechanical Engineering at The University of Arizona. I established the Experimental and Computational Heat Transfer Laboratory in 1988, which I directed until 2005.

8. From 2004 to 2006, I was the Program Director of Thermal Transport and Thermal Processing in the Chemical and Transport Systems Division of The National Science Foundation, managing a $6.5 million program that, under my tenure, was awarded in excess of $12 million in grants in emerging areas of thermal science. From 2005 to 2006, I was the Program Coordinator of the Active Nanostructures and Nanosystems NIRT Program, coordinating the efforts of 15 programs across the engineering directorate, which was awarded $35 million in grants in the area of nanoengineering. While at the National Science Foundation, I initiated a major workshop on Emerging Frontiers in Thermal Transport, with the goal of identifying emerging topics and helping the National Science Foundation to define the thermal transport research agenda for the next decade.

9. I joined the faculty of Mechanical Engineering at Villanova University as the James R. Birle Professor of Technology in 2006. That same year, I established the Laboratory for Advanced Thermal and Fluid Systems, which is the focal point for my research in fundamentals and applications of heat transfer in thermal-fluid systems. From 2007 to 2016, I served as Associate Dean for Graduate Studies and Research and Associate Vice President for Research and Graduate Programs, having administrative oversight over all graduate programs and research initiatives in the College of Engineering.

10. From 2017 to 2018, I served as Dean of the School of Engineering and John M. Sobrato Professor of Engineering at Santa Clara University. I have also served as a Visiting Professor, in the Departamento de Ingeniería Mecanica y Metalurgica (Department of Mechanical and Metallurgical Engineering) at Pontificia Universidad Catolica de Chile (Pontifical Catholic University of Chile) in Santiago, Chile, and in the Department of Mechanical Engineering at Binghamton University.

11. I returned to Villanova University in 2018, and am currently the James R. Birle Endowed Chair Professor of Energy Technology. I also serve as the co-director of the Villanova University Strategic Initiative for Climate, Justice, and Sustainability; director of the Villanova University Laboratory for Advanced Thermal and Fluid Systems; and director of the National Science

Foundation Industry/University Cooperative Research Center on Energy Smart Electronic Systems.

12. I am the author of over 300 journal and symposium papers, book chapters, and monographs. I have presented numerous invited lectures on these subjects nationally and internationally, and I am a frequent short course instructor on the subject. I have held visiting positions at The National Institute of Standards and Technology and the Technical University at Delft, the Netherlands, and I have served on international doctoral committees in Sweden, the Netherlands, and South Korea.

13. I am an internationally recognized authority in the cooling of electronic systems, convective and conjugate heat transfer in complex flows, and experimental measurements in the thermal sciences. I have conducted extensive academic research in the areas of electronics cooling and thermal management in data centers; in particular, experimental, analytical, and numerical investigation of thermal issues in electronic packaging; conjugate heat transfer; air cooling; impingement cooling; liquid cooling; two-phase cooling; spray cooling; micro- and mini-channels; hybrid air-liquid cooling; and dynamic cooling. I have authored numerous articles and papers relating to thermal management of electronic systems, including "Design of Air and Water Cooled Heat Exchangers for Electronics Cooling: A Critical Review of Data and Analysis Methods for Heat Sinks and Cold Plates," published at the 26th IEEE Semiconductor Thermal Measurement, Modeling, and Management Symposium in 2010; and "Transitioning from Air to Liquid Cooling: Design Fundamentals for Heat Sinks and Cold Plates" published at the 28th IEEE Semiconductor Thermal Measurement, Modeling, and Management Symposium in 2012.

14. I am a member of the American Society of Mechanical Engineers, and have served as an Editor of the Journal of Heat Transfer, Journal of Electronic Packaging, and IEEE Transactions on Components, Packaging, and Manufacturing Technology.

15. I am a former Chair of the ASME K16 Committee on Heat Transfer in Electronic Equipment (1993-1997) and of the ASME Electronic and Photonic Packaging Division (2001-2002). I was the General Chair of the ASME/IEEE ITHERM Symposium (1994), the IEEE SEMITHERM Symposium (1994), and the 2005 ASME International Electronic and Photonic Packaging Conference (InterPACK 2005). I am also the recipient of the 2001 ASME Electronic Packing Division Thermal Management Award, and the 2002 IEEE SEMITHERM Significant Contributor Award.

Prior Testimony

16. A detailed list of my prior testimony is attached as **Exhibit C**.

Compensation

17. I am being compensated for my time spent on this matter at my standard rate of $840.00 per hour for time spent testifying at deposition or trial, and $740.00 per hour for all other work. My compensation is in no way contingent on the outcome of this litigation or the content of my particular testimony or opinions. I otherwise have no financial interest in the litigation or connection to the parties.

RELEVANT LEGAL PRINCIPLES

18. I have relied on certain legal principles in forming my opinions. My understanding of these legal principles is based on counsel's explanation of them. I summarize my understanding of these legal principles below.

19. I understand that the America Invents Act ("AIA"), which changed certain patent laws and rules, applies to patents with a priority date on or after March 16, 2013.

20. I understand that MGT contends the earliest date of invention and the priority date of all Asserted Claims of the Asserted Patents is, respectively, March 14, 2012 and December 14, 2012.[5] I further understand that Rhodium contends the Asserted Claims of the Asserted Patents are not entitled to either of these dates, and the priority date of the Asserted Patents is instead December 13, 2013, the filing date of the '457 patent.

21. Consequently, the following section summarizes my understanding of both the pre-AIA and post-AIA legal principles.

Inventorship

22. I understand that an "inventor" is an individual or individuals who invented or discovered the subject matter of an invention. An individual who contributes to the subject matter of an invention is a "joint inventor" or "coinventor" when they: (1) contribute in some significant manner to the conception or reduction to practice of the invention; (2) make a contribution to the claimed invention that is not insignificant in quality, when that contribution is measured against the dimension of the full invention, and (3) do more than merely explain to the real inventors well-known concepts and/or the current state of the art.

23. I also understand that a patent that does not list the names of its true inventors is invalid for improper inventorship. A patentee may correct an error in a patent's list of inventors; however, a patent is invalid for inequitable conduct where a patentee has withheld material information regarding inventorship with an intent to mislead the United States Patent and Trademark Office ("PTO").

Priority Date

24. I understand that the "priority date" of claims of a patent determines whether a reference is "prior art" to the claims. I also understand that when the priority date is based on the filing of a patent application, the priority date is the earliest effective filing date of the patent's claims. I understand that the earliest effective filing date of a patent's claims may predate the actual filing date of the application for that patent. For example, if a nonprovisional (utility) application claims priority to an earlier provisional application, the earliest effective filing date of the claims resulting from the nonprovisional application may be the filing date of the provisional application, but only if the provisional application's disclosure satisfies the enablement and written description requirements (discussed below) for those claims.

[5] *See* Pl.'s Supp. Resp. to Defs.' Interrog. No. 2, Apr. 5, 2023.

Prior Art

25. I understand that the patent statutes describe categories of prior art. Specifically, I understand that the pre-AIA statutory framework of 35 U.S.C. § 102 reads as follows:

> A person shall be entitled to a patent unless—
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> (a) the invention was known or used by others in this country, or patented or described in a printed publication in this or a foreign country, before the invention thereof by the applicant for patent, or
>
> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of the application for patent in the United States, or
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> ***
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> (e) the invention was described in—(1) an application for patent, published under section 122(b), by another filed in the United States before the invention by the applicant for patent or (2) a patent granted on an application for patent by another filed in the United States before the invention by the applicant for patent, except that an international application filed under the treaty defined in section 351(a) shall have the effects for the purposes of this subsection of an application filed in the United States only if the international application designated the United States and was published under Article 21(2) of such treaty in the English language;
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> (g) . . . (2) before such person's invention thereof, the invention was made in this country by another inventor who had not abandoned, suppressed, or concealed it. In determining priority of invention under this subsection, there shall be considered not only the respective dates of conception and reduction to practice of the invention, but also the reasonable diligence of one who was first to conceive and last to reduce to practice, from a time prior to conception by the other.[6]

26. I also understand that the post-AIA statutory framework of 35 U.S.C. § 102 reads as follows:

> (a) NOVELTY; PRIOR ART.—A person shall be entitled to a patent unless—

[6] 35 U.S.C. § 102 (2011).

(1) the claimed invention was patented, described in a printed publication, or in public use, on sale, or otherwise available to the public before the effective filing date of the claimed invention; or

(2) the claimed invention was described in a patent issued under section 151, or in an application for patent published or deemed published under section 122(b), in which the patent or application, as the case may be, names another inventor and was effectively filed before the effective filing date of the claimed invention.

(b) EXCEPTIONS.—

(1) DISCLOSURES MADE 1 YEAR OR LESS BEFORE THE EFFECTIVE FILING DATE OF THE CLAIMED INVENTION.—A disclosure made 1 year or less before the effective filing date of a claimed invention shall not be prior art to the claimed invention under subsection (a)(1) if—

(A) the disclosure was made by the inventor or joint inventor or by another who obtained the subject matter disclosed directly or indirectly from the inventor or a joint inventor; or

(B) the subject matter disclosed had, before such disclosure, been publicly disclosed by the inventor or a joint inventor or another who obtained the subject matter disclosed directly or indirectly from the inventor or a joint inventor.

(2) DISCLOSURES APPEARING IN APPLICATIONS AND PATENTS.—A disclosure shall not be prior art to a claimed invention under subsection (a)(2) if—

(A) the subject matter disclosed was obtained directly or indirectly from the inventor or a joint inventor;

(B) the subject matter disclosed had, before such subject matter was effectively filed under subsection (a)(2), been publicly disclosed by the inventor or a joint inventor or another who obtained the subject matter disclosed directly or indirectly from the inventor or a joint inventor; or

(C) the subject matter disclosed and the claimed invention, not later than the effective filing date of the claimed invention, were owned by the same person or subject to an obligation of assignment to the same person.

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> (d) PATENTS AND PUBLISHED APPLICATIONS EFFECTIVE AS PRIOR ART.—For purposes of determining whether a patent or application for patent is prior art to a claimed invention under subsection (a)(2), such patent or application shall be considered to have been effectively filed, with respect to any subject matter described in the patent or application—
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> (1) if paragraph (2) does not apply, as of the actual filing date of the patent or the application for patent; or
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> (2) if the patent or application for patent is entitled to claim a right of priority under section 119, 365(a), 365(b), 386(a), or 386(b), or to claim the benefit of an earlier filing date under section 120, 121, 365(c), or 386(c) based upon 1 or more prior filed applications for patent, as of the filing date of the earliest such application that describes the subject matter.[7]

27. I understand that prior art can take the form of written reference such as patents and printed publications, and can also take the form of system reference including products. I understand that where the prior art takes the form of a product/system, the characteristics and prior use of that product/system can be proven with testimony and documentary evidence.

28. I also understand that an invention was "on sale" if the invention was: (a) the subject of a commercial sale or offer for sale and (b) ready for patenting. I further understand that an invention is "ready for patenting" when (1) the invention is reduced to practice or (2) the invention is depicted in drawings or described in writings in enough detail for a person having ordinary skill in the art to be able to make the invention.

29. The following is a list of systems and references that I understand are prior art to the Asserted Patents:

- U.S. Patent No. 10,123,463 ("Best '463");
- The Green Revolution Cooling Tank ("Best Tank");
- U.S. Patent Application Publication No. 2014/0211412 ("Best Publication");
- U.S. Patent No. 5,167,511 ("Krajewski '511");
- U.S. Patent Application Publication No. 2006/0126292 ("Pfahnl Publication");
- Russian Federation Patent No. 2,500,013 ("Gryzhin '013");
- U.S. Patent No. 3,406,244 ("Oktay '244");

[7] 35 U.S.C. § 102 (2015).

- Japanese Patent No. JPH04116758 ("JP '758");
- U.S. Patent No. 9,992,914 ("Best '914");
- U.S. Patent No. 6,555,298 ("Rolfson '298");
- U.S. Patent No. 4,590,538 ("Cray '538");
- U.S. Patent No. 5,448,108 ("Quon '108");
- U.S. Patent No. 8,009,419 ("Attlesey '419");
- U.S. Patent No. 7,403,392 ("Attlesey '392");
- U.S. Patent Application Publication No. 2008/0017355 ("Attlesey Publication").

30. I understand that these system and references constitute prior art to the Asserted Patents under both the pre-AIA and post-AIA statutory framework of 35 U.S.C. § 102.

Person of Ordinary Skill in the Art

31. I understand that an analysis of the claims of a patent should be undertaken from the perspective of a person having ordinary skill in the art ("POSA") at the time of the purported invention. A POSA is a hypothetical person who analyzes prior art without the benefit of hindsight. A POSA is presumed to have knowledge of all references that are sufficiently related to one another and to the pertinent art and to have knowledge of all arts reasonably pertinent to the particular problem that a claimed invention addresses.

32. I understand that to determine the appropriate level of a POSA, the following factors may be considered: (a) the types of problems encountered by those working in the field and prior art solutions thereto; (b) the sophistication of the technology in question, and the rapidity with which innovations occur in the field; (c) the educational level of active workers in the field; and (d) the educational level of the inventor.

33. In my opinion, as of the time of the purported invention, a POSA in the field of the Asserted Patents would have had a working knowledge of immersion cooling systems. The POSA would have either (1) a bachelor's degree in mechanical engineering, or an equivalent degree, and five years of professional experience, including with responsibility for designing immersion cooling systems or (2) a master's degree in mechanical engineering, or an equivalent degree, including study in liquid cooling systems design and research. Lack of professional experience can be remedied by additional education, and vice versa.

Written Description, Enablement, and Indefiniteness

34. I understand that a claim must be supported by a written description of the invention within the four corners of the specification. It is my understanding that the disclosure in the specification must be full, clear, and exact enough to allow a POSA to recognize that the inventor invented what is claimed and possessed the claimed invention as of the filing date associated with the patent. I

understand that it is not enough if what is described in the disclosure renders the claimed invention obvious. I understand that, rather, every claim limitation must be present expressly or inherently in the original specification ("inherently" meaning the claimed feature is necessarily present in what is expressly described).

35. I understand that a patent must disclose sufficient information to enable or teach a POSA to make and use the full scope of the claimed invention without undue experimentation, as of the priority date associated with the patent for the claimed invention.

36. I also understand from counsel that there are many factors to be considered when determining whether there is sufficient evidence to support a determination that a disclosure does not satisfy the enablement requirement and whether any necessary experimentation is "undue." These factors include, but are not limited to, the breadth of the claims; nature of the invention; state of the prior art; level of one of ordinary skill; level of predictability in the art; amount of direction provided by the inventor; existence of working examples; and quantity of experimentation needed to make or use the invention based on the content of the disclosure.

37. I understand that the claims must match what the applicant regarded as the claimed invention. I understand that a patent must be precise enough to afford clear notice of what is claimed and provide a POSA with a clear understanding of the patent's limitations and boundaries. It is my understanding that, when the patent and prosecution history are read together, they should disclose a single known method, arrangement, or combination or establish that, if there are multiple known methods, arrangements, or combinations, a POSA would know which approach to choose.

Anticipation

38. I understand that determining whether a patent claim is anticipated is a two-step process. In the first step, the language of the claim is construed as it would be understood by a POSA at the time of the purported invention of the Asserted Patents. The claim is construed by referring to intrinsic evidence, which includes the claim language, the patent specification, and the prosecution history, as well as extrinsic evidence. The words of patent claims are to be given their ordinary and customary meaning unless the inventor has defined them (acted as their own lexicographer) or used them differently (i.e., in a manner inconsistent with the ordinary and customary meaning). The prosecution history of a patent, and related patents and applications, may limit the interpretation of the claim, especially if the patentee disavowed or disclaimed any claim scope in order to obtain allowance of the claim.

39. I understand that the parties have agreed to construction of the term "weir" to mean "an overflow structure or barrier that determines the level of liquid;" and of the term "plenum" to mean "a structure for dispensing liquid."[8] I have considered and used these constructions in my analysis and opinions. In the absence of a claim construction, I have applied my understanding of how one of ordinary skill in the art would interpret the term at the time of the purported invention.

40. I further understand that in a prior patent infringement action, *Midas Green Technologies, LLC v. Immersion Systems LLC*, No. 4:20-cv-00555-O (N.D. Tex. 2020), which concerned the

[8] Joint Stipulation on Claim Construction, ECF No. 50.

Asserted Patents, the court issued a claim construction order and held that the terms "a weir . . . adapted to facilitate substantially uniform recovery" and "a weir . . . having an overflow lip adapted to facilitate substantially uniform recovery" are not indefinite, and construed those terms as having their plain and ordinary meaning.[9] I understand that the court also understood the terms to have the same meaning.[10] I have applied my understanding of how one of ordinary skill in the art would interpret these terms at the time of the purported invention.

41. In the second step of the anticipation analysis, one must perform a comparison of the properly construed claims to the prior art on a limitation-by-limitation basis. I understand that, for a reference to be anticipatory, it must expressly or inherently disclose every element of each asserted claim and be arranged or combined in the same way as each asserted claim. If a prior art reference does not expressly arrange or combine all of the limitations in the claimed invention, I understand that the reference may still be anticipatory if a POSA, when reading the reference, would know that the limitations would need to be arranged or combined in that way. Similarly, I also understand that a feature is inherent in a prior art system where a POSA would know that the feature is necessarily required in the system.

42. I also understand that anticipation cannot be established by combining references unless they are expressly incorporated by reference. However, I understand that other references may be used to interpret an anticipating reference by, for example, indicating how a POSA would understand the anticipating reference, or to demonstrate the inherency of certain disclosures within the reference.

Obviousness

43. I understand that obviousness is analyzed from the perspective of a POSA at the time of the purported invention. I also understand that a POSA is presumed to have been aware of all pertinent prior art at the time of the purported invention.

44. I understand that an obviousness analysis involves comparing a claim to the prior art to determine whether the claimed invention, as a whole, would have been obvious to a POSA in view of the prior art and in light of the general knowledge in the art at the time of the purported invention.

45. It is further my understanding that obviousness can be established by combining or modifying the disclosures of prior art references to achieve the claimed invention. A claimed invention is obvious where at the time of the claimed invention, a POSA would have been motivated to combine the disclosures of the prior art references to achieve the claimed invention, taking into account such factors as (1) whether the claimed invention was merely the predictable result of using prior art elements according to their known function(s); (2) whether the claimed invention provides an obvious solution to a known problem in the relevant field; (3) whether the prior art teaches or suggests the desirability of combining elements claimed in the invention; (4) whether the prior art teaches away from combining elements in the claimed invention; and (5) whether it would have been obvious to try the combinations of elements, such as when there is a

[9] Claim Construction Order, *Midas Green Technologies, LLC v. Immersion Systems LLC*, No. 4:20-cv-00555-O (N.D. Tex. Nov. 22, 2021), ECF No. 84.
[10] *See id.* at 7.

design incentive or market pressure to solve a problem and there are a finite number of identified, predictable solutions. It is also my understanding that, where there is a reason to modify or combine the prior art to achieve the claimed invention, there must also be a reasonable expectation of success in so doing to render the claimed invention obvious.

46. I understand that the reason to combine prior art references can come from a variety of sources, not just the prior art itself or the specific problem the patentee or author was trying to solve. I also understand that the references themselves need not provide a specific hint or suggestion of the alteration needed to arrive at the claimed invention; the analysis may include recourse to logic, judgment, and common sense available to a POSA.

47. I understand that, when considering the obviousness of an invention, one should also consider whether there are any objective indicia that support the non-obviousness of the invention. I further understand that objective indicia of non-obviousness include failure of others, copying, unexpected results, information that "teaches away" from the claimed subject matter, perception in the industry, commercial success, and long-felt but unmet need. I also understand that, in order for objective indicia of non-obviousness to be applicable, the indicia must have some sort of nexus to the subject matter in the claim that was not known in the art. I understand that this nexus includes a factual connection between the patentable subject matter of the claim and the objective indicia alleged. I also understand that an independently made invention that is made within a comparatively short period of time is evidence that the claimed invention was the product of ordinary skill.

Duty of Candor

48. I understand that all patent applicants, their attorneys or agents, and everyone else involved in the preparation or prosecution of a patent application must abide by a duty of candor. I understand the duty of candor to require disclosure of all information known to the individual that is material to patentability, including all known relevant prior art. I understand that information is material when it is not cumulative to information already disclosed in the patent application, and (1) it establishes, by itself or in combination with other information, unpatentability of a claim; or (2) it refutes, or is inconsistent with, a position the applicant takes in: (i) opposing an argument of unpatentability relied on by the PTO, or (ii) asserting an argument of patentability.

49. I understand inequitable conduct is a defense to patent infringement that, if established, renders a patent unenforceable. Inequitable conduct is established upon clear and convincing evidence that a patent applicant knew of a prior art reference, knew that the reference was material, and made a deliberate decision not to disclose the reference to the PTO. A reference is material if the PTO would not have allowed a claim had it been aware of the undisclosed reference.

Presumption of Validity

50. I understand that claims of an issued patent are presumed to be valid, meaning that it was properly granted by the PTO. I also understand that this presumption of validity can be overcome if clear and convincing evidence is presented that proves the patent is invalid. It is my understanding that for evidence to be clear and convincing, it must produce in the mind of the finder of fact an abiding conviction that the truth of the factual contentions is highly probable.

SUMMARY OF OPINIONS AND CONCLUSIONS

51. Where the Court or the parties have provided a construction for a claim term, I have adopted that construction. For all other claim terms, I have analyzed the claim under my understanding of the term and/or under the interpretation put forth by MGT in its infringement contentions.

Summary of Opinions and Conclusion on Anticipation and Obviousness

52. As explained more clearly below, it is my opinion that the Asserted Patents do not include any new or novel material in any instance. In my opinion, the Asserted Claims of the '457 patent are invalid on the following grounds:

a. Best '463 alone or in combination with the general knowledge and common sense of those skilled in the art and/or the teachings of one or more of the Best Tank, the Best Publication, Best '914, Oktay '244, Krajewski '511, the Pfahnl Publication, Gryzhin '013, JP '758, Rolfson '298, Attlesey '419, and Quon '108;

b. The Best Publication alone or in combination with the general knowledge and common sense of those skilled in the art and/or the teachings of one or more of the Best Tank, Best '463, Best '914, Oktay '244, Krajewski '511, the Pfahnl Publication, Gryzhin '013, JP '758, Rolfson '298, Attlesey '419, and Quon '108;

c. The Best Tank alone or in combination with the general knowledge and common sense of those skilled in the art and/or the teachings of one or more of the Best Publication, Best '463, Best '914, Oktay '244, Krajewski '511, the Pfahnl Publication, Gryzhin '013, JP '758, Rolfson '298, Attlesey '419, and Quon '108;

d. Krajewski '511 alone or in combination with the general knowledge and common sense of those skilled in the art and/or the teachings of one or more of the Best Tank, the Best Publication, Best '463, Best '914, Oktay '244, the Pfahnl Publication, Gryzhin '013, JP '758, Rolfson '298, Attlesey '419, and Quon '108;

e. The Pfahnl Publication alone or in combination with the general knowledge and common sense of those skilled in the art and/or the teachings of one or more of the Best Tank, the Best Publication, Best '463, Best '914, Oktay '244, Krajewski '511, Gryzhin '013, JP '758, Rolfson '298, Attlesey '419, and Quon '108;

f. Gryzhin '013 alone or in combination with the general knowledge and common sense of those skilled in the art and/or the teachings of one or more of the Best Tank, the Best Publication, Best '463, Best '914, Oktay '244, Krajewski '511, the Pfahnl Publication, JP '758, Rolfson '298, Attlesey '419, and Quon '108;

g. Oktay '244 alone or in combination with the general knowledge and common sense of those skilled in the art and/or the teachings of one or more of the Best Tank, the Best Publication, Best '463, Best '914, Krajewski '511, the Pfahnl Publication, Gryzhin '013, JP '758, Rolfson '298, Attlesey '419, and Quon '108;

h. JP ‘758 alone or in combination with the general knowledge and common sense of those skilled in the art and/or the teachings of one or more of the Best Tank, the Best Publication, Best ‘463, Best ‘914, Oktay ‘244, Krajewski ‘511, the Pfahnl Publication, Gryzhin ‘013, Rolfson ‘298, Attlesey ‘419, and Quon ‘108; and

i. Best ‘914 alone or in combination with the general knowledge and common sense of those skilled in the art and/or the teachings of one or more of the Best Tank, the Best Publication, Oktay ‘244, Krajewski ‘511, the Pfahnl Publication, Gryzhin ‘013, JP ‘758, Rolfson ‘298, Attlesey ‘419, and Quon ‘108.

53. In addition, as explained more clearly below, in my opinion, the Asserted Claims of the ‘446 patent are also invalid on the following grounds:

a. Best ‘463 alone or in combination with the general knowledge and common sense of those skilled in the art and/or the teachings of one or more of the Best Tank, the Best Publication, Best ‘914, Oktay ‘244, Krajewski ‘511, the Pfahnl Publication, Gryzhin ‘013, JP ‘758, Rolfson ‘298, Attlesey ‘419, and Quon ‘108;

b. The Best Publication alone or in combination with the general knowledge and common sense of those skilled in the art and/or the teachings of one or more of the Best Tank, Best ‘463, Best ‘914, Oktay ‘244, Krajewski ‘511, the Pfahnl Publication, Gryzhin ‘013, JP ‘758, Rolfson ‘298, Attlesey ‘419, and Quon ‘108;

c. The Best Tank alone or in combination with the general knowledge and common sense of those skilled in the art and/or the teachings of one or more of the Best Publication, Best ‘463, Best ‘914, Oktay ‘244, Krajewski ‘511, the Pfahnl Publication, Gryzhin ‘013, JP ‘758, Rolfson ‘298, Attlesey ‘419, and Quon ‘108;

d. Krajewski ‘511 alone or in combination with the general knowledge and common sense of those skilled in the art and/or the teachings of one or more of the Best Tank, the Best Publication, Best ‘463, Best ‘914, Oktay ‘244, the Pfahnl Publication, Gryzhin ‘013, JP ‘758, Rolfson ‘298, Attlesey ‘419, and Quon ‘108;

e. The Pfahnl Publication alone or in combination with the general knowledge and common sense of those skilled in the art and/or the teachings of one or more of the Best Tank, the Best Publication, Best ‘463, Best ‘914, Oktay ‘244, Krajewski ‘511, Gryzhin ‘013, JP ‘758, Rolfson ‘298, Attlesey ‘419, and Quon ‘108;

f. Gryzhin ‘013 alone or in combination with the general knowledge and common sense of those skilled in the art and/or the teachings of one or more of the Best Tank, the Best Publication, Best ‘463, Best ‘914, Oktay ‘244, Krajewski ‘511, the Pfahnl Publication, JP ‘758, Rolfson ‘298, Attlesey ‘419, and Quon ‘108;

g. Oktay ‘244 alone or in combination with the general knowledge and common sense of those skilled in the art and/or the teachings of one or more of the Best Tank, the Best Publication, Best ‘463, Best ‘914, Krajewski ‘511, the Pfahnl Publication, Gryzhin ‘013, JP ‘758, Rolfson ‘298, Attlesey ‘419, and Quon ‘108;

h. JP ‘758 alone or in combination with the general knowledge and common sense of those skilled in the art and/or the teachings of one or more of the Best Tank, the Best Publication, Best ‘463, Best ‘914, Oktay ‘244, Krajewski ‘511, the Pfahnl Publication, Gryzhin ‘013, Rolfson ‘298, Attlesey ‘419, and Quon ‘108; and

i. Best ‘914 alone or in combination with the general knowledge and common sense of those skilled in the art and/or the teachings of one or more of the Best Tank, the Best Publication, Oktay ‘244, Krajewski ‘511, the Pfahnl Publication, Gryzhin ‘013, JP ‘758, Rolfson ‘298, Attlesey ‘419, and Quon ‘108.

54. My detailed analysis of the Asserted Claims of the ‘457 patent is presented in claim charts as identified in the table below.

	‘457 PATENT
Exhibit	**Reference**
Exhibit D-1	**Best ‘463** alone or in combination with the general knowledge and common sense of those skilled in the art and/or the teachings of one or more of: Best Publication Best Tank Oktay ‘244 JP ‘758 Pfahnl Application Krajewski ‘511 Gryzhin ‘013 Best ‘914 Rolfson ‘298 Quon ‘108 Attlesey ‘419 Anticipation and obviousness for all asserted claims.
Exhibit D-2	**Best Publication** alone or in combination with the general knowledge and common sense of those skilled in the art and/or the teachings of one or more of: Best ‘463 Best Tank Oktay ‘244 JP ‘758 Pfahnl Application Krajewski ‘511 Gryzhin ‘013 Best ‘914 Rolfson ‘298 Quon ‘108

	Attlesey ‘419 Anticipation and obviousness for all asserted claims.
Exhibit D-3	**Best Tank** alone or in combination with the general knowledge and common sense of those skilled in the art and/or the teachings of one or more of: Best ‘463 Best Publication Oktay ‘244 JP ‘758 Pfahnl Application Krajewski ‘511 Gryzhin ‘013 Best ‘914 Rolfson ‘298 Quon ‘108 Attlesey ‘419 Anticipation and obviousness for all asserted claims.
Exhibit D-4	**Oktay ‘244** in combination with the general knowledge and common sense of those skilled in the art and/or the teachings of one or more of: Best ‘463 Best Publication Best Tank JP ‘758 Pfahnl Application Krajewski ‘511 Gryzhin ‘013 Best ‘914 Rolfson ‘298 Quon ‘108 Attlesey ‘419 Obviousness for all asserted claims.
Exhibit D-5	**JP ‘758** in combination with the general knowledge and common sense of those skilled in the art and/or the teachings of one or more of: Best ‘463 Best Publication

	Best Tank Oktay '244 Pfahnl Application Krajewski '511 Gryzhin '013 Best '914 Rolfson '298 Quon '108 Attlesey '419 Obviousness for all asserted claims.
Exhibit D-6	**Pfahnl Application** in combination with the general knowledge and common sense of those skilled in the art and/or the teachings of one or more of: Best '463 Best Publication Best Tank Oktay '244 JP '758 Krajewski '511 Gryzhin '013 Best '914 Rolfson '298 Quon '108 Attlesey '419 Obviousness for all asserted claims.
Exhibit D-7	**Krajewski '511** in combination with the general knowledge and common sense of those skilled in the art and/or the teachings of one or more of: Best '463 Best Publication Best Tank Oktay '244 JP '758 Pfahnl Application Gryzhin '013 Best '914 Rolfson '298 Quon '108 Attlesey '419 Obviousness for all asserted claims.

Exhibit D-8	**Gryzhin '013** in combination with the general knowledge and common sense of those skilled in the art and/or the teachings of one or more of: Best '463 Best Publication Best Tank Oktay '244 JP '758 Pfahnl Application Krajewski '511 Best '914 Rolfson '298 Cray '538 Quon '108 Attlesey '419 Obviousness for all asserted claims.
Exhibit D-9	**Best '914** alone or in combination with the general knowledge and common sense of those skilled in the art and/or the teachings of one or more of: Best '463 Best Publication Best Tank Oktay '244 JP '758 Pfahnl Application Krajewski '511 Gryzhin '013 Rolfson '298 Cray '538 Quon '108 Attlesey '419 Anticipation and obviousness for all asserted claims.

55. My detailed analysis of the Asserted Claims of the '446 patent is presented in claim charts as identified in the table below.

	'446 PATENT
Exhibit	Reference
Exhibit E-1	**Best '463** alone or in combination with the general knowledge and common sense of those skilled in the art and/or the teachings of one or more of: Best Publication Best Tank Oktay '244 JP '758 Pfahnl Application Krajewski '511 Gryzhin '013 Best '914 Rolfson '298 Quon '108 Attlesey '419 Anticipation and obviousness for all asserted claims.
Exhibit E-2	**Best Publication** alone or in combination with the general knowledge and common sense of those skilled in the art and/or the teachings of one or more of: Best '463 Best Tank Oktay '244 JP '758 Pfahnl Application Krajewski '511 Gryzhin '013 Best '914 Rolfson '298 Quon '108 Attlesey '419 Anticipation and obviousness for all asserted claims.

Exhibit E-3	**Best Tank** alone or in combination with the general knowledge and common sense of those skilled in the art and/or the teachings of one or more of: Best '463 Best Publication Oktay '244 JP '758 Pfahnl Application Krajewski '511 Gryzhin '013 Best '914 Rolfson '298 Quon '108 Attlesey '419 Anticipation and obviousness for all asserted claims.
Exhibit E-4	**Oktay '244** in combination with the general knowledge and common sense of those skilled in the art and/or the teachings of one or more of: Best '463 Best Publication Best Tank JP '758 Pfahnl Application Krajewski '511 Gryzhin '013 Best '914 Rolfson '298 Quon '108 Attlesey '419 Obviousness for all asserted claims.
Exhibit E-5	**JP '758** in combination with the general knowledge and common sense of those skilled in the art and/or the teachings of one or more of: Best '463 Best Publication Best Tank Oktay '244 Pfahnl Application

	Krajewski ‘511 Gryzhin ‘013 Best ‘914 Rolfson ‘298 Quon ‘108 Attlesey ‘419 Obviousness for all asserted claims.
Exhibit E-6	**Pfahnl Application** in combination with the general knowledge and common sense of those skilled in the art and/or the teachings of one or more of: Best ‘463 Best Publication Best Tank Oktay ‘244 JP ‘758 Krajewski ‘511 Gryzhin ‘013 Best ‘914 Rolfson ‘298 Quon ‘108 Attlesey ‘419 Obviousness for all asserted claims.
Exhibit E-7	**Krajewski ‘511** in combination with the general knowledge and common sense of those skilled in the art and/or the teachings of one or more of: Best ‘463 Best Publication Best Tank Oktay ‘244 JP ‘758 Pfahnl Application Gryzhin ‘013 Best ‘914 Rolfson ‘298 Quon ‘108 Attlesey ‘419 Obviousness for all asserted claims.

Exhibit E-8	**Gryzhin '013** in combination with the general knowledge and common sense of those skilled in the art and/or the teachings of one or more of: Best '463 Best Publication Best Tank Oktay '244 JP '758 Pfahnl Application Krajewski '511 Best '914 Rolfson '298 Cray '538 Quon '108 Attlesey '419 Obviousness for all asserted claims.
Exhibit E-9	**Best '914** alone or in combination with the general knowledge and common sense of those skilled in the art and/or the teachings of one or more of: Best '463 Best Publication Best Tank Oktay '244 JP '758 Pfahnl Application Krajewski '511 Gryzhin '013 Rolfson '298 Cray '538 Quon '108 Attlesey '419 Anticipation and obviousness for all asserted claims.

Summary of Opinions and Conclusion on the Priority Date of the Asserted Patents

56. As explained more clearly below, it is my opinion that that the provisional applications, U.S. Provisional Patent Application No. 61/737,200, filed on December 14, 2012 ("2012 Provisional") and U.S. Provisional Patent Application No. 61/832,211, filed on June 7, 2013 ("2013 Provisional"),[11] to which the Asserted Patents claim priority, do not describe the claimed

[11] 2012 Provisional at MIDAS0004047; 2013 Provisional at MIDAS0004155.

invention and the manner of making and using it such that a POSA would be able to make the claimed invention without undue experimentation. In particular, the provisional applications do not adequately teach or enable the following limitations of the Asserted Patents:

a. "a weir, integrated horizontally into the long wall of the tank adjacent all appliance slots, having an overflow lip adapted to facilitate substantially uniform recovery of the dielectric fluid flowing through each appliance slot;" and

b. "a plenum . . . adapted to dispense the dielectric fluid substantially uniformly upwardly through each appliance slot."

57. The 2013 Provisional does not describe or depict "a weir" or "a plenum."[12] In addition, the 2012 Provisional does not identify a "plenum" or describe a "plenum . . . adapted to dispense the dielectric fluid substantially uniformly upwardly through each appliance slot." The 2012 Provisional describes horizontally-oriented[13] or radially-arranged[14] spray heads that share dielectric fluid flowing in interconnected piping. It is my opinion that these spray heads would not dispense dielectric fluid "substantially uniformly upwardly," and instead would, as disclosed, exhibit uneven flow rates. Moreover, the spray cooling system illustrated in the 2013 Provisional is not an immersion cooling system; it uses fluids to cool the appliances by spraying them on the surface.

58. The 2012 Provisional also shows a drawing labeled "possible slotted outflow manifold profile" that would presumably be a form of a coolant inlet. The 2012 Provisional describes that the "slotted outflow manifold" is connected to a tube through which cold fluid flows into a tank.[15] The 2012 Provisional states that the size of the slots or holes of the manifold would need to be progressively wider to account for loss of cold fluid pressure. This too fails to describe or teach achieving flow of fluid "substantially uniformly upwardly" for two reasons. First, the 2012 Provisional gets the applicable principles exactly backwards. The holes should be wider near the entrance because the pressure is lower near the entrance and the fluid velocity is higher. As the flow slows across the length of the tube, one could then make holes smaller to increase the pressure. Second, to achieve substantially uniform upward flow through each appliance slot, there must be some way both to make the fluid flow turn upwards and to guarantee that it is uniform. That is difficult to do, and the 2012 Provisional does not even comment on the problem, much less propose a solution to it.

59. Likewise, the 2012 Provisional does not describe "a weir, integrated horizontally into the long wall of the tank adjacent all appliance slots, having an overflow lip adapted to facilitate substantially uniform recovery of the dielectric fluid flowing through each appliance slot." The 2012 Provisional describes "open return channel(s) (e.g., weirs) extending horizontally along the long side(s) of the tank."[16] However, the description does not teach or enable a structure that

[12] *See generally* 2013 Provisional at MIDAS0004155.
[13] 2012 Provisional at MIDAS0004057.
[14] *Id.* at MIDAS0004057.
[15] *Id.* at MIDAS0004082.
[16] *Id.* at MIDAS0004055.

"determines the level of liquid in a tank," is "adjacent all appliance slots," and facilitates substantially uniform recovery of the dielectric fluid.

60. It is thus my opinion that the provisional applications do not disclose all of the limitations of the Asserted Claims of the Asserted Patents in a manner that satisfies the written description and enablement requirements.

Summary of Opinions and Conclusion on Written Description and Enablement

61. As explained more clearly below, it is my opinion that the Asserted Patents do not adequately teach the following limitations:

a. "a weir . . . adapted to facilitate substantially uniform recovery of the dielectric fluid through each appliance slot;"

b. "a plenum . . . adapted to dispense the dielectric fluid substantially uniformly upwardly through each appliance slot."

62. The plenum as depicted and described in the Asserted Patents would not achieve the purposes of a plenum, nor would it achieve the goal recited by the claims, namely, substantially uniform upward flow through each appliance slot. In particular, the Asserted Patents do not teach how to size or arrange the holes in the orifice plate of the plenum to achieve substantially uniform upward flow through each appliance slot, and a POSA would not know how to achieve the claimed substantially uniform upward flow without considerable additional work and experimentation.

63. Similarly, the weir as depicted and described in the Asserted Patents would not facilitate uniform recovery of the dielectric fluid because the level of the surface of the fluid, which is established by the vertical position of the weir, appears to coincide with the top of the electrical appliances. The details provided in the Asserted Patents about the outflow weir is limited such that a POSA would not know how to achieve the claimed weir adapted to facilitate substantially uniform recovery of the dielectric fluid without considerable additional work and experimentation.

64. I reserve the right to amend my opinions based on arguments put forth by MGT and/or constructions from the Court that bear on this issue. I further reserve the right to create illustrations and demonstrations to support my conclusions at trial.

BACKGROUND OF TECHNOLOGY

Electronic Systems Packaging

65. Electronic systems require electrical power in order to perform their intended electrical function such as computing, processing of data, or lighting. Electronic systems that perform digital computations, i.e. computing systems, require electrical power that increases proportionately to the speed at which they compute, i.e. the processing speed. Every new generation of electronic processors, such as Application Specific Integrated Circuits (ASICs), Central Processing Units (CPUs), Programmable Gate Arrays (PGAs), and Graphics Processing Units (GPUs) are denser and faster and therefore require more power. ASICs and PGAs are the primary type of processor used to perform the mathematical computations required to support digital currency, i.e. bit coin

mining, whereas CPUs and GPUs are primarily used in high speed on-line transactions, performing complex mathematical computations such as in AI applications, and high speed data processing as for example in graphics and video streaming.

66. Most of the electrical power supplied to electronic processors eventually is dissipated as heat, a phenomenon that has been experienced by anyone that owns a cellphone or laptop. The faster and more intense the required computational processing, the higher the electrical power required by the electronics performing the processing. And the higher the electrical power, the higher is the rate at which heat is created. Just as humans must dissipate their generated heat during intense exercise in order to stay "cool," electronic systems must also dissipate their generated heat, otherwise they will overheat and fail.

67. The processors that are at the heart of all computing systems are composed of integrated electronic circuits built on silicon substrates, commonly referred to as "silicon chips." Electronic computing systems may have many such chips connected to each other, and to other necessary devices, such memory. In order to protect the fragile silicon integrated circuit, the silicon chips are mounted onto chip carriers or "packages." Figure 1 illustrates examples of different types of electronic packages, sometimes referred to as "chip carriers."

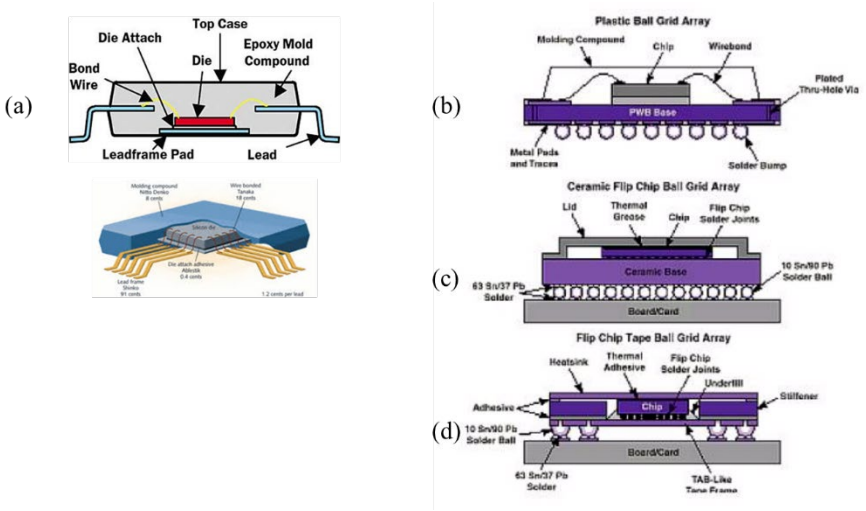


Figure 1. Examples of electronic packages and components: (a) plastic encapsulated surface mount quad flat pack;[17] (b) plastic ball grid array (BGA); (c) ceramic flip chip BGA; (d) flip chip tape BGA.[18]

[17] Bennett Joiner, *Integrated-circuit-package-types-and-thermal-characteristics*, Electronics Cooling (Feb. 1, 2006), https://www.electronics-cooling.com/2006/02/integrated-circuit-package-types-and-thermal-characteristics/#.

[18] *Microcircuits*, United States Navy Naval Sea Systems Command, http://www.navsea.navy.mil/Home/Warfare-Centers/NSWC-Crane/Resources/SD-18/Products/Microcircuits/Packaging/.

68. Each of the electronic packages illustrated in Fig. 1 has a silicon chip or "die" that has the electronic circuit that performs the computations for which it is designed. For example, in Bit-Coin mining, the chip circuit is used to perform extremely fast calculations that use large numbers and hence require massive amount of computational speed to do the "mining." Performing those computations requires electrical energy, i.e. power, to open and close the millions of switches on the chip circuit that fundamentally perform the computation.

Thermal Management Systems

69. The First Law of Thermodynamics[19] teaches that energy in equals energy out. In electronic systems the "energy in" is electrical energy or power. The electrical power is delivered to the chip circuit from a power source, like the electrical socket on a wall, through wiring and into the chip, and the "energy out" is heat. This "conservation of energy" embodied in the First Law is demonstrated in Figure 2 on a typical electronic package. The purpose of the thermal management system is to efficiently remove the heat from the electronic components so as to maintain a targeted temperature. The targeted temperature is generally the operating temperature of the chip as shown in Figure 2.

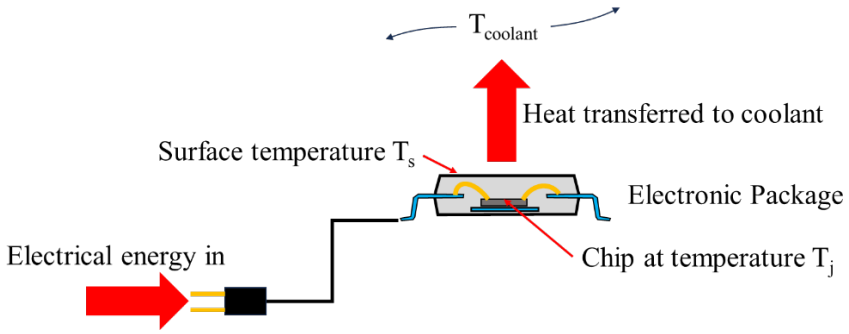


Figure 2. Power delivered to the electronic chip circuit is converted to heat that flows out of the package and into the coolant.

70. In an electronic package, such as that shown in Figure 2, the heat is generated within the silicon chip at the integrated circuit. The generated heat causes the silicon chip temperature to increase. This chip temperature is called the chip "junction temperature" and is given the symbol: T_J. It is well-established that elevated chip junction temperatures may cause the integrated circuit to immediately fail if it is extremely high, for example as what occurs in the case of an electrical short. Just as importantly, elevated chip junction temperatures will shorten the useful life of the electronic system by increasing the probability of failure.[20] As such, chip and package manufacturers routinely establish recommended chip junction temperatures during operational use in systems; typically, maximum junction temperatures are established between 80 to 100 C. A

[19] Michael Moran & Howard Shapiro, *Fundamentals of Engineering Thermodynamics* 52 (6th ed. 2008).
[20] Allan Kraus & Avram Bar-Cohen, *Thermal Analysis and Control of Electronic Equipment* 34–35 (1983).

thermal management system capable of "cooling" the electronic system and maintaining adequate chip junction temperatures is thus an essential requirement for all systems.

Air Cooling

71. At the heart of all electronic processing assemblies are the electronic packages housing the chip processors that perform the computational work. An electronic system is a hierarchical system built from components that must receive electrical power, communicate with each other, and transmit information to the outside world. The chip circuit is the first level in the hierarchy, followed by the chip, then the chip package. The packages are themselves mounted onto the printed circuit boards ("PCBs") which are the fourth hierarchical level and are common building blocks for assembling any modern electronic system. The PCB facilitates the electrical connections that deliver power to the package and allow the chip to communicate with other devices such as processors or memory chips. PCBs are connected to a common backplane which provides the interface for passing information between the system and the outside world.

72. Figure 3 shows an air-cooled electronic assembly consisting of packages mounted on PCBs cooled by an air-cooling system. The PCB is the green-colored board that is familiar to anyone who has looked inside any device that is powered by electricity. The printed circuit board is mounted inside an enclosure that may contain multiple such boards, and other devices such as power supplies. The grey structure called a "heat sink" is mounted on top of the package and is used to increase the area in contact with the cooling air.

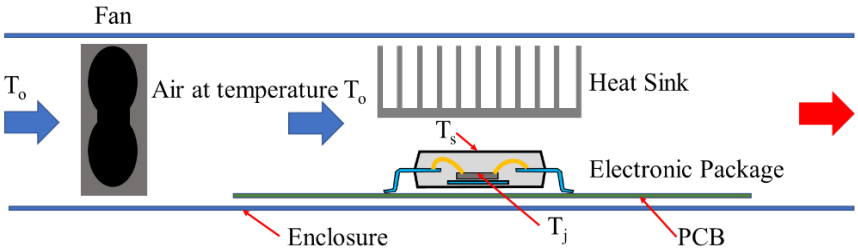


Figure 3. An electronic package mounted inside an air-cooled electronic enclosure.

73. The photograph in Figure 4 shows a modern air-cooled electronic server which is the type of "computer" that is used to power the internet. Here one can observe the fans, the PCB, multiple electronic components, and the heat sinks that are mounted on top of some of the electronic packages to facilitate the heat transfer.

It is important to point out here that the purpose of the cooling air is to keep the chip circuit temperature, commonly referred to as the junction temperature, T_j low enough so that the chip circuit does not fail and so that it has a long life. For heat to be transferred from the hot chip to the air, the air temperature, T_o, must be lower than the chip temperature.

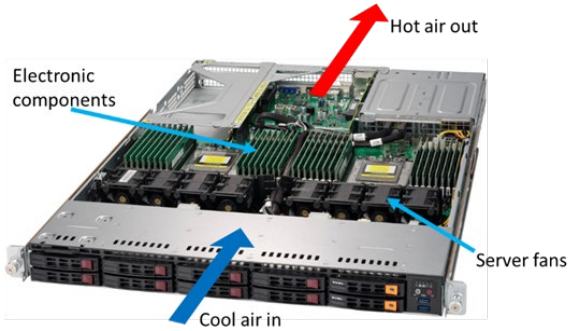


Figure 4. A modern air-cooled electronic server used in data centers powering the internet.

Immersion Cooling

74. The amount of heat generated in the processing of bit-coin data exceeds the limits that can be cooled with air, as in the air-cooled server technology shown in Figure 4. Hence, it is necessary to use liquid to cool the hot chips because liquid has a higher capacity for removing heat from surfaces compared to gases such as air. Furthermore, basic physics shows that is more efficient to place the electronic system directly into the liquid because then the liquid is in direct contact with the hot electronic package surfaces, thus facilitating the transfer of heat. Figure 5 is a basic illustration of how this is accomplished using what is referred to as "immersion cooling."

75. The illustration in Figure 5 is simplified to show the basic features of a direct immersion cooling system. What is depicted is direct immersion cooling of an electronic enclosure containing many heated electronic components such as chip packages. A bit-coin "miner" used in the generation of digital currency is an example of such an enclosure. There are two types of immersion cooling: (1) single phase immersion cooling, in which the liquid remains a liquid throughout and the transfer of heat is accomplished by the "single phase convective heat transfer" from the hot surfaces to the liquid;[21] (2) two-phase immersion cooling, in which the liquid changes from liquid to vapor, i.e. it "boils" as it picks up heat from the hot components. This type of heat transfer is called "pool boiling." The Asserted Patents describe systems that use single-phase immersion cooling. In the remainder of this report, the "cooling system" will refer to a single-phase direct immersion cooling system.

[21] G. P. Peterson & Alfonso Ortega, *Thermal Control of Electronic Equipment and Devices*, *in* 20 ADVANCES IN HEAT TRANSFER 243-244 (J. P. Hartnett & T. F. Irvine, Jr. ed., 1990).

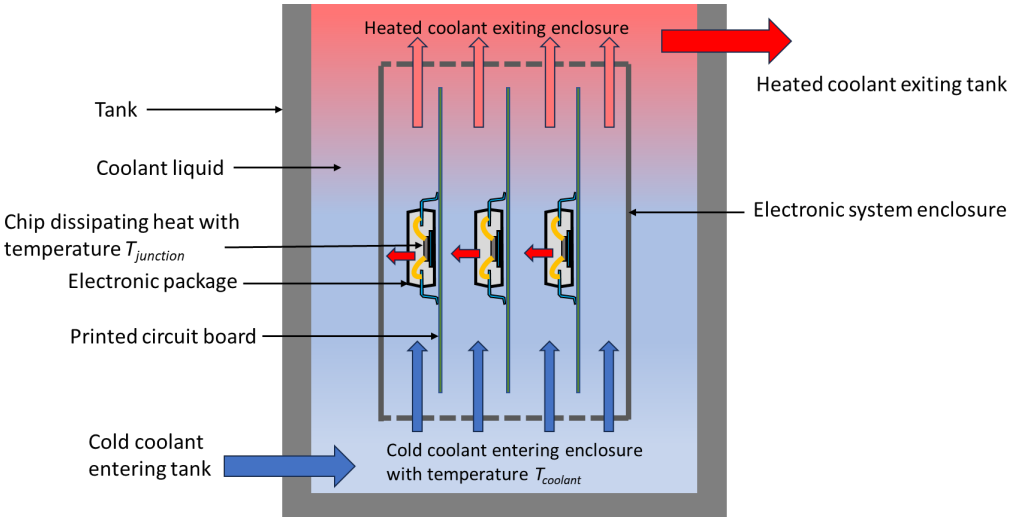


Figure 5. Direct immersion liquid cooling of electronic enclosure; depicted is a single tank with a single electronic enclosure with many electronic printed circuit boards and components.

Mechanisms of Heat Transfer from the Chip Junction to the Coolant

76. In an immersion cooling system as shown in Figure 5, there are two basic mechanisms involved in the transfer of heat from the heated chip to the coolant liquid. Figure 6 is an exploded view of one single electronic package, labeled for clarity.

Conduction

77. Heat transfer through solids takes place by conduction heat transfer. Conduction occurs by molecular mechanisms.[22] Energetic molecules can vibrate and collide with their neighbors—this intermolecular collisional motion causes the transfer of energy at the molecular level from a higher temperature to a lower temperature region. Solids such as metals are better at conducting heat than liquids and gases. Metals, such as copper, are better thermal conductors than non-metallic solids, such as plastic or the epoxy-fiberglass material used in printed circuit boards. In Figure 6, the transfer of heat from the heated chip to the solid materials of the electronic package is by conduction.

Convection

78. Convection heat transfer occurs when the liquid is in contact with a surface that is at a dissimilar temperature.[23] At the surface of a heated solid, heat is conducted from the surface to the fluid. The heat conducted into the fluid is absorbed and swept away by the fluid motion. The combined mechanisms of fluid conduction, absorption into the fluid, and fluid motion constitute

[22] Theodore L. Bergman & Adrienne S. Lavine, *Fundamentals of Heat and Mass Transfer* 18 (8th ed. 2019).
[23] *Id;* Gordan N. Ellison, *Thermal Computations for Electronics: Conductive, Radiative and Convective Air Cooling* 5 (2011).

the mechanism of convection heat transfer.[24] As seen in Figure 6, the heated surfaces of the electronic component transfer heat by convection to the upward moving coolant liquid. Furthermore, since heat is being added to the coolant fluid, its temperature increases, as illustrated in Figure 5.

Thermal Resistance

79. One of the most well-known laws of Thermodynamics is the basic law of heat transfer which states that heat can only flow in the direction from high temperature to low temperature.[25] Furthermore, as with electricity, heat always flows through the path of least resistance. Both of these physical observations are captured by the simple principle of the thermal resistance, $R_{thermal}$.[26] In the presence of a temperature difference, $\Delta T = T_{high} - T_{low}$, the rate at which heat is conducted through a thermal pathway is given by:

$$Q = \frac{\Delta T}{R_{thermal}} \quad (1)$$

where Q is the heat transferred per unit time. $R_{thermal}$ represents the resistance to heat flow introduced by all of the materials and thermal mechanisms in the thermal pathway from T_{high} to T_{low}.

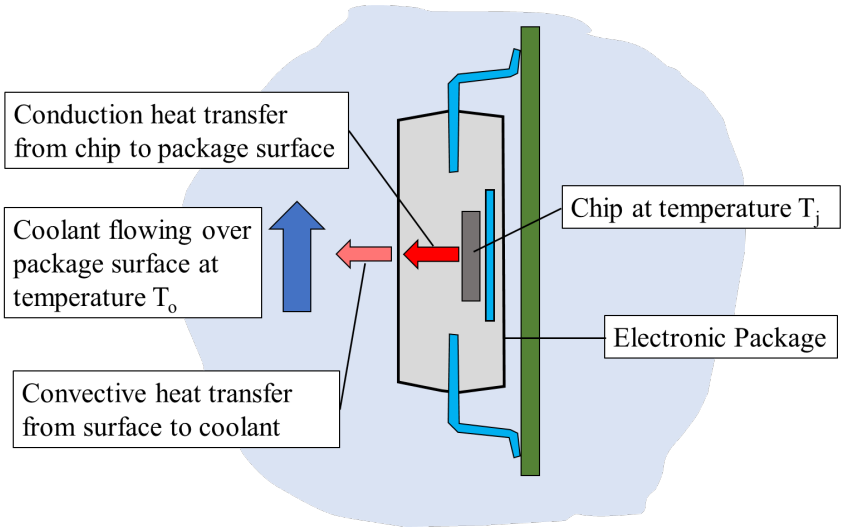


Figure 6. Transfer of heat from a chip at temperature T_j to a coolant liquid at temperature T_o flowing over the electronic package surfaces.

[24] Robert Moffat & Alfonso Ortega, *Direct Air Cooling of Electronic Components*, *in* 1 ADVANCES IN THERMAL MODELING OF ELECTRONIC COMPONENTS AND SYSTEMS 129–132 (Avram Bar-Cohen & Allan Kraus ed., 1988).
[25] William C. Reynolds & Henry C. Perkins, *Engineering Thermodynamics* 203 (1977).
[26] *See* Bergman & Lavine, *supra,* at 18.

80. The relationship between heat flow and temperature difference given in Equation 1 is commonly depicted in graphical form by noting the one-to-one relationship between Equation 1 and Ohm's Law:[27]

$$V = I \times R \tag{2}$$

where V is voltage, I is current, and R is resistance. Equation 1 can be re-written as:

$$\Delta T = Q \times R_{thermal} \tag{3}$$

81. In this form it can be interpreted as a "thermal" Ohms law; temperature difference ΔT corresponds to voltage drop V, heat flow Q corresponds to electrical current I, and thermal resistance $R_{thermal}$ corresponds to electrical resistance R. The thermal Ohm's law can be shown graphically as in Figure 7.[28] Here it is seen that the heat flow must pass through the thermal resistance due to the combined effects of solid materials conduction and fluid convection and this heat flow is caused by the difference between the high and low temperatures, i.e. ΔT.

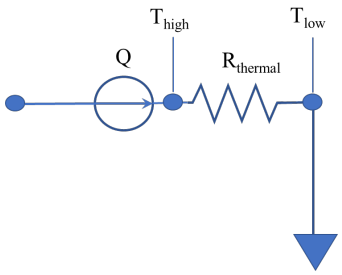


Figure 7. A simple thermal circuit showing that heat flow results from a high temperature to a low temperature through a thermal resistance.

82. For the immersion cooling scenario shown in Figs. 5 and 6, the high temperature is the chip junction, T_j, and the low temperature is the liquid coolant, T_o. Clearly, the chip junction temperature is not equal to the liquid coolant temperature. They are related by Equation 1 as:

$$T_j = T_o + Q \times R_{thermal} \tag{4}$$

Conduction and Convection Thermal Resistance

83. The thermal resistance is composed of the sum of the conduction thermal resistance due to the solid materials and the convection resistance due to the finite properties and speed of the coolant flow over the heated surfaces, i.e.:

$$R_{thermal} = R_{conduction} + R_{convection} \tag{5}$$

[27] Edward M. Purcell, *Electricity and Magnetism: Berkeley Physics Course-Volume 2* 114–115 (1963).
[28] *See* Bergman & Lavine, *supra,* at 18.

84. The convection resistance given in Equation 5 is strongly dependent on the interaction between the liquid flowing over the heated surfaces. In particular, it is strongly proportional to the velocity (speed) of the coolant. The type of flow exhibited by immersion cooling oil flowing in tanks is called "laminar flow." For laminar flow, it is well established that the convection thermal resistance, $R_{convection}$, is inversely proportional to the square of the flow velocity, i.e.:

$$R_{convection} = Constant/V^2 \quad (6)$$

85. Equation 6 shows that the higher the flow velocity, the lower is the convection resistance. Equations 4, 5, and 6 teach that in order to maintain the proper chip junction temperature, the coolant flow must have sufficient velocity as it flows over the hot components to reduce the convection resistance to a suitably low level. Equations 4, 5, and 6 establish the key requirements of an effective cooling system. Given the total thermal load, i.e. the total amount of heat Q that must be dissipated, the following must be met:

a. The thermal management system must maintain the junction temperature T_j to its proper level.
b. The coolant temperature T_o entering the system must be sufficiently low to absorb the thermal load.
c. The overall thermal resistance $R_{thermal}$ must be low enough to allow the transfer of the heat from the chip junction to the coolant over the temperature difference: $\Delta T = T_j - T_o$.
d. The coolant flow must be in contact over sufficient heated surface area with sufficient velocity in order for the convection resistance to be suitably low.

In summary, the chip junction temperature T_j is related to the coolant temperature, but they are not the same. Their relationship depends on the amount of heat being transferred and the value of the overall thermal resistance connecting the chip junction to the liquid coolant. This thermal resistance is strongly dependent on the architecture of the electronic assembly, the properties of the solid materials (in particular the thermal conductivity and diffusivity), the properties of the coolant (in particular its thermal conductivity, diffusivity, and viscosity) and the velocity magnitude and distribution around the electronic assembly.

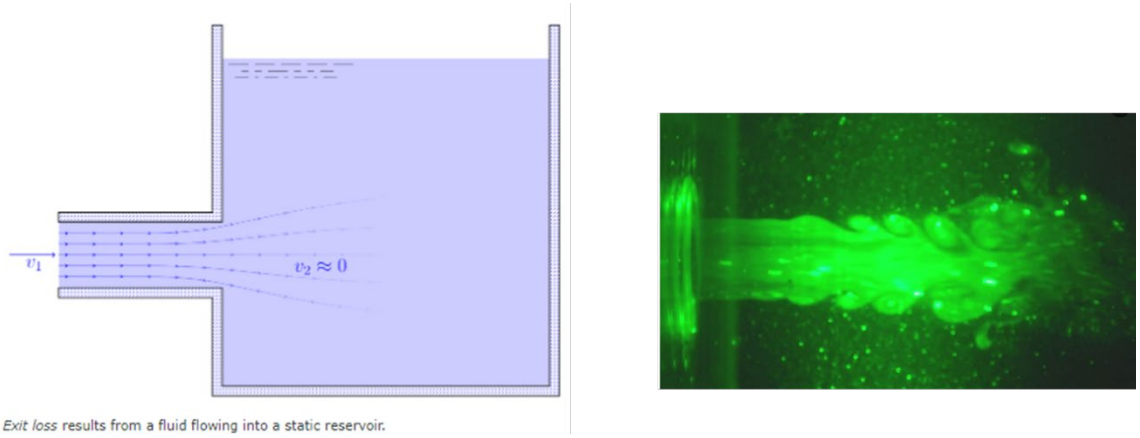
Flow Management

86. The system shown in Figure 5 illustrates the general concepts utilized in cooling electronics with single phase immersion cooling. As described in the previous section, not only is it necessary to provide the liquid coolant at sufficient flow rate and low enough temperature to absorb the thermal load from the electronics, we also require that the liquid flow be in intimate contact with the surface area of the heated components and have sufficient velocity to drive the convective resistance sufficiently low to meet the targeted overall thermal resistance. The purpose of flow management is to ensure that flows behave in their intended manner in the system in question. In liquid cooling systems, the task is to ensure that the fluid flow is distributed to where it needs to flow with sufficient flow rate and velocity. Large liquid flow systems, be they home water systems

or large, complex petro-chemical refineries, are generally constructed from piping networks that convey the fluid from one component to another. Typical components in a liquid cooling system include tanks, pumps, heat exchanger, valves, and the piping network consisting of straight sections of pipe of different sizes, and many minor components such as Tees and Elbows. Elements of the overall cooling system are described in a subsequent section. Here we focus on the flow management for tanks which are integral to this type of electronics cooling system.

87. The immersion tank of Figure 5 is connected on the inflow side to a pipe which delivers the cold coolant from the heat exchanger back to the tank. If a flow enters a large environment from a small opening, such as a pipe opening, it creates what is termed a "submerged free jet." Figure 8 shows an illustration of the free jet that forms when the flow enters the tank (a.) and photographic details of the flow features in a free jet taken in a water tank (b.). If the goal is to create a flow that fills the vessel with uniform flow, upward flow as seen in Figure 5, it is clear that active measures need to be taken to allow the jet to transition to the tank flow either naturally or with intervention.

Figure 8. (a.) Free jet created from flow in a circular pipe into a large fluid volume;[29] (b.) Details of the complex structure of a submerged free jet.[30]



[29] Kevin Dusling, *Energy loss due to friction*, https://kdusling.github.io/teaching/Applied-Fluids/Notes/FrictionLosses.
[30] Edson Del Rio Vieira et al., *Vortex Formation In Incompressible Axisymmetric Free Jets*, Energia Térmica, http://dx.doi.org/10.5380/reterm.v13i2.62100.

88. Methods for managing and controlling liquid flows such as this are well known. For example, Owen and Peake[31] and Beckner and Curry[32] describe the flow management utilized in a research quality water tunnel at NASA Ames-Dryden Research Center, Figure 9.

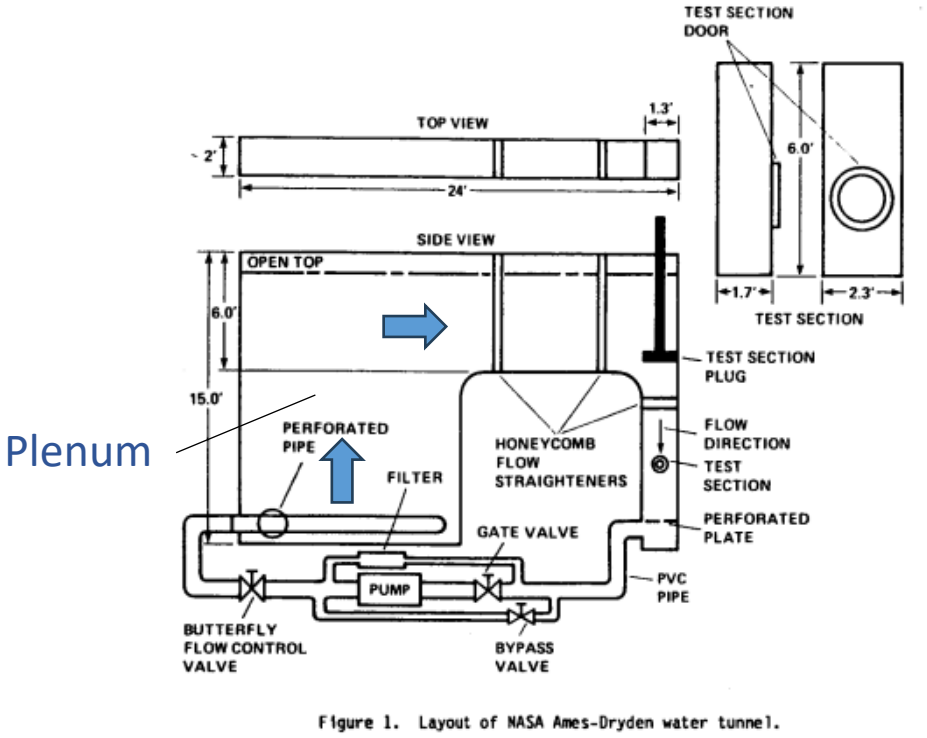


Figure 9. Schematic of the NASA Ames water tunnel, circa 1985 (annotated).[33]

89. The purpose of this water tunnel is to create a uniform flow of water in the test section shown on the right of the figure. Uniform flow means that the flow is all in one direction and has the same velocity everywhere in the rectangular duct upstream of the test section. On the left side of the image is a large rectangular volume where the water enters. In flow management systems, this volume is called a "settling chamber" or "plenum." The author has added the work "plenum" to the figure pointing to this region of the figure. A plenum or settling chamber is a volume large enough to allow the water flow to transition or settle from the inlet pipe flow to the duct flow in the water tunnel. Note that the water passes through the pump and into the inlet pipe on the bottom left of the plenum.

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[31] F.K. Owen & D.J. Peake, *Vortex breakdown and control experiments in the Ames-Dryden Water Tunnel*, NASA Technical Memorandum 89410 (Nov. 1986), https://ntrs.nasa.gov/api/citations/19870003976/downloads/19870003976.pdf

[32] Christine Beckner & Robert E. Curry, *Water Tunnel Flow Visualization Using a Laser*, NASA Technical Memorandum 86743, (Oct. 1985), https://ntrs.nasa.gov/api/citations/19860001739/downloads/19860001739.pdf

[33] Owen & Peake, *supra*.

Perforated Pipe or Inlet Manifold

90. In order to accelerate this transition and distribute the flow more uniformly, the flow is made to enter through a perforated pipe at the bottom of the settling chamber instead of entering the plenum as a single free jet. This is a pipe with many orifices or perforations. By forcing the water to exit through these many orifices, the water issues into the settling chamber as many smaller lower flow, lower momentum jets. The momentum of these smaller jets is more easily dissipated, causing the jets to merge more rapidly into a more uniform upward flow. This transition continues in the plenum. If properly designed, the perforated pipe should cause the velocity and flow of each of the many jets issuing from it to be the same, thus promoting uniformity in the flow as it enters the plenum.

91. The perforated pipe is an example of what is more generally termed a "distribution manifold." A distribution manifold is used to force a single pipe with a large flow rate to distribute into many smaller flows—this is accomplished by spacing smaller orifices or holes along the length of the pipe. Figure 10 shows the basic configuration. The length of the arrows represents the velocity of the flow and it shows various types of maldistribution of flow that can occur in the manifold. The competing effects of fluid friction, which would tend to decrease the pressure, and flow deceleration, which would tend to increase the pressure, will cause the flow leaving the orifices to be non-uniform as in cases B, C, and D in the figure. A proper design to ensure uniform flow must take into account many factors including the total flow rate, the size of the main pipe, and the size and spacing of the secondary orifices. It is not necessary for the orifices to be the same size, but introducing orifices of different sizes introduces further complexities. Minota[34] illustrates the complex calculations needed in order to understand the coupled physics and to predict the flow distribution.

Plenum

92. In the context of flow management systems, a plenum is an open volume in a tank or duct that is used to allow an unsettled flow to "relax" or "settle." It is also called a "settling chamber," and consistent with this, the patent refers to its "plenum facility" as comprising an "orifice plate" (the perforated plate atop the plenum) and a "plenum chamber."[35] An unsettled flow may contain turbulence or vortices generated from upstream components such as a distribution manifold. These flow features dissipate by viscosity if given sufficient "time," i.e. length of flow. Hence, the size of the plenum or settling chamber is not arbitrary—it is designed with sufficient volume to allow the inlet free jet structures to merge and disappear into a more uniform flow. The volume necessary for this to happen is related to the distance required for the free jet momentum to dissipate. I understand the Court has construed "plenum" to mean "a structure for dispensing liquid." This definition captures the plenum's function in flow management of ensuring that flow emerging from the plenum will be more uniform as a result of having been settled.

[34] Nitin Minocha & Jyeshtharaj B. Joshi, *3D CFD simulation of turbulent flow distribution and pressure drop in a dividing manifold system using openfoam*, Intl. J. Heat Mass Transfer (April 2020), https://doi.org/10.1016/j.ijheatmasstransfer.2020.119420.
[35] See '457 patent at 4:12-15, Figs. 1, 8 and 9.

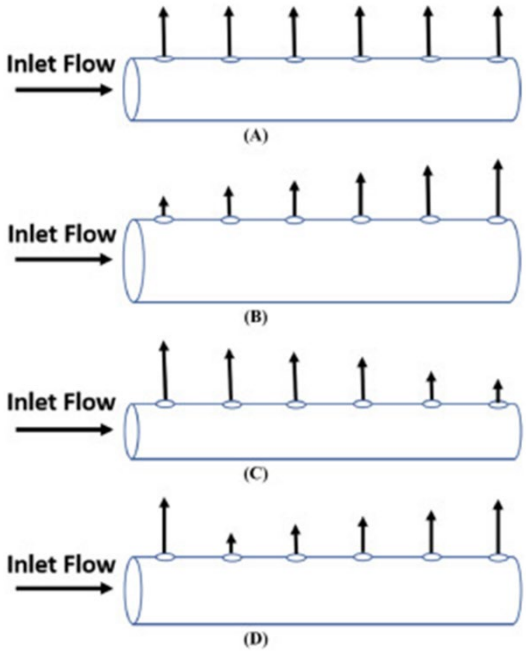


Figure 10. A distribution manifold showing a uniform flow leaving orifices (A) compared to cases with varying degrees of flow friction and flow deceleration (B, C, D).[36]

Flow Straighteners

93. In the water tunnel of Figure 9, as the flow exits the plenum and enters the upper horizontal duct, one further measure is taken to force the flow to achieve uniformity, the inclusion of two banks of honeycomb flow straighteners intercepting the duct. Honeycomb flow straighteners are structures with many identical flow channels adjacent to each other. They can easily be imagined as what would emerge if one created a bundle of drinking straws. The honeycomb "straightens out" the flow, meaning it causes the flow to flow in one direction only—it removes any remnant flow structures that may have survived from their birth in the free jets emanating from the perforated pipe. Other types of structures can be used as flow straighteners including panels of wire mesh or perforated plates. Because flow will distribute itself in order to find the path of "least resistance," the natural tendency for flows encountering flow straighteners or perforated plates or other obstacles, is to flow equally through all of the openings, thus causing the flow to become more uniform and with velocity or motion only in one direction. The presence of a flow straightener of itself will not guarantee flow uniformity—it must be coupled with a sufficiently well-designed upstream plenum that allows the flow to approach the flow straighteners with a good degree of uniformity—the flow straightener or perforated plate or mesh finishes the job.

[36] *Id.*

Secondary Flows Caused by Geometry

94. Other types of troublesome secondary flow structures commonly emerge in the flow of liquids in tanks and ducts. Any kind of abrupt change in the walls of a duct or vessel may cause the emergence of secondary vortex structures. Figure 11 shows two common secondary flows. The first (a.) is the recirculating flow structures that emerge in a sudden expansion in a duct or pipe. The second (b.) occurs upon a sudden contraction in a duct or pipe. The reason for both of these secondary vortex structures is that the flow cannot suddenly change directions—because of its own momentum, the flow cannot "turn the corner," thus causing the flow to generate these corner vortices. Secondary vortex structures are difficult to wash away. They cause flows to be unsteady and introduce non-uniformities in the flow velocities. In the design of well-managed flow system, it is imperative to eliminate any sources of secondary flows including sharp corners, sudden changes in flow area, or features that cause a sudden change in flow direction.

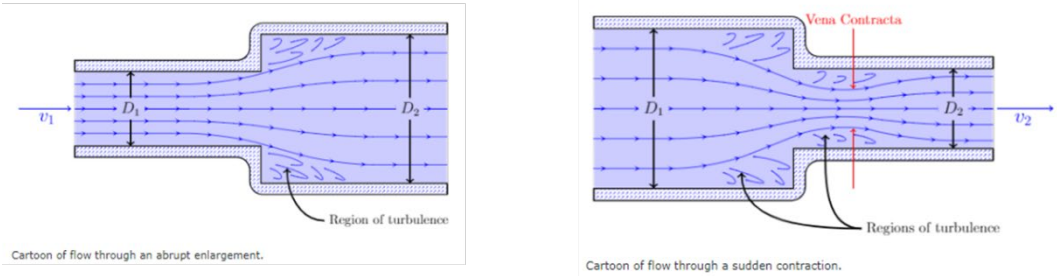


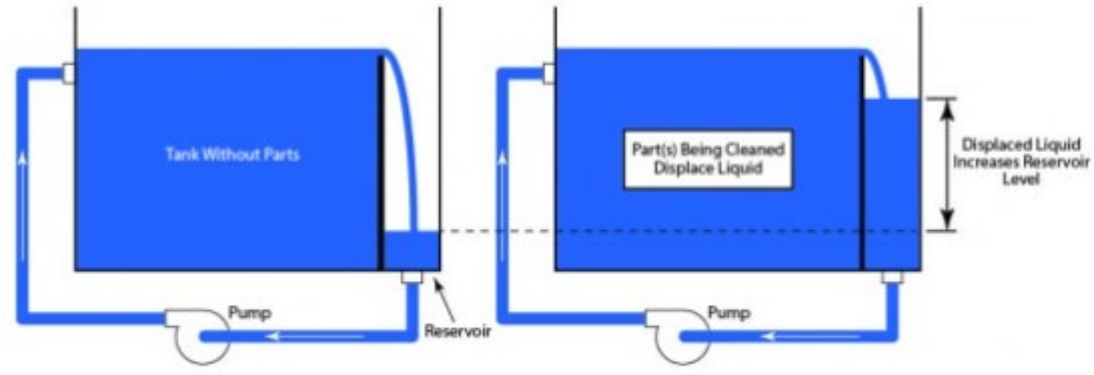
Figure 11. (a.) Secondary vortices in a pipe or duct with a sudden expansion (a.) and contraction (b.)

Overflow Weirs

95. In naturally occurring vessels or channels that have a free surface, such as lakes, canals, and rivers, the use of overflow dams is a common way to control the level of the surface. The level of the water cannot exceed the level of the overflow dam for then the water pours over the dam. The Oxford dictionary defines a weir as "a low dam built across a river to raise the level of water upstream or regulate its flow." Historical understanding of dams and weirs no doubt has influenced the adoption of weirs in industrial applications where controlling the level and flow in a vessel or tank is required. In industrial cleaning tanks for example, where it is necessary to immerse a manufactured part in a vessel of cleaning fluid with an open top, overflow weirs have been adopted to control the level of the tank fluid during continuous flow. Figure 10 illustrates an overflow tank used in an industrial cleaning application. As shown in the figure, the weir plate holds back the liquid in the tank and establishes its level. The overflow cascades over the weir and into a reservoir adjacent to the tank where the flow is collected and delivered to the pump. The part is cleaned by the continuously circulating fluid. There are various types of weirs used in industrial tanks. Figure 13 (a.) shows a plain weir which is a plate with a continuous "lip" on the top surface. One of the problems encountered with plain weirs such as this is that perturbations in the liquid surface may cause "rivulets" or disturbances along the lip which may cause flow non-uniformity. In order to counter these effects, weirs have been developed which contain various types of cut-outs or indentations on the weir lip. Figure 13(b.) shows a "saw-tooth" weir which has V-shaped cut-outs on the lip. These evenly spaced saw-tooth cut-outs cause the flow to cascade in evenly spaced falls

which assures uniformity. Figure 14 shows an industrial cleaning tank with sawtooth weirs along its periphery. Note the use of an overflow reservoir on the sides of the main tank which catches the overflow liquid, as illustrated in Figure 12.

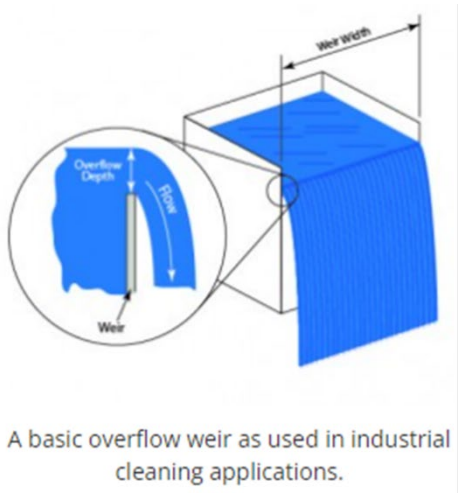
96. The illustrations in Figure 13 show a plane weir—a weir that spans a side of the tank. A weir composed of a channel that does not span the entire side of the vessel could also be utilized in the same manner as a plane weir. For example, Figure 15 illustrates a pipe or channel attached to the tank wall such that the level of the free surface is established by the level of the overflow in the pipe or channel. In this case the pipe or channel has a naturally formed lip over which the flow cascades, as shown in the illustration.



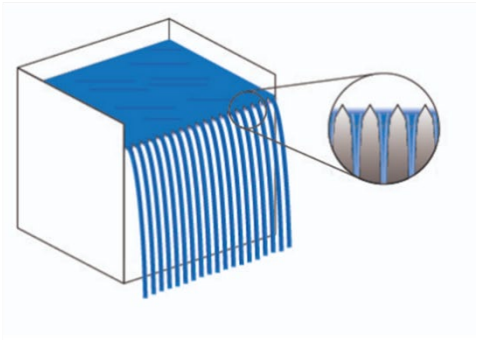
An overflow weir maintains liquid level as liquid is displaced as parts are introduced into the process tank.

Figure 12. An overflow weir used in an industrial cleaning tank.[37]

[37] John Fuchs, *Maximizing Overflow Weirs for Skimming Applications*, Cleaning Technologies Group (Oct. 31, 2014), https://techblog.ctgclean.com/2014/10/making-overflow-weirs-work/.



A basic overflow weir as used in industrial cleaning applications.



A "saw-tooth" weir is one way to assure uniform flow over a weir at low liquid flow rates.

(a.) (b.)

Figure 13. Types of overflow weirs used in an industrial cleaning tanks; (a.) plain overflow weir; (b.) Saw-tooth weir used to assure uniform flow.[38]

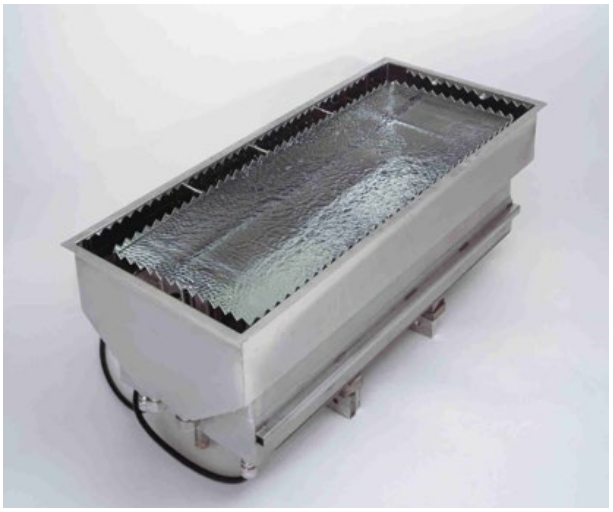


Figure 14. An industrial cleaning tank equipped with saw-tooth weirs on its perimeter; note that the liquid overflow cascades into a reservoir adjacent to the main tank.[39]

[38] *Id.*

[39] *Precision Cleaning Equipment,* https://web.archive.org/web/20080820004735/http://www.ultracleanequip.com/prec_clean.htm (archived August 20, 2008).

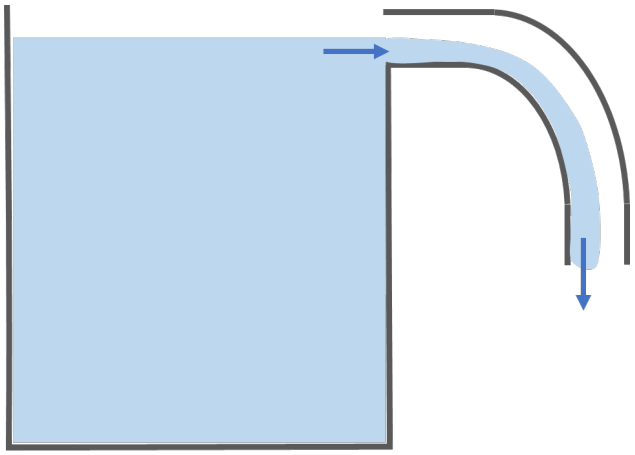


Figure 15. An overflow weir consisting of an open or closed pipe or channel with a free surface.

Overflow Weir used in Immersion Cooling Tanks

97. In immersion cooling tanks for electronic equipment, overflow weirs have been developed for designs that require a free surface for ease of placing or removing the electronic components into the immersion tank. In a patent for an immersion cooling approach for electronic equipment, Oktay '244 describes an embodiment in which electronics are immersed in a single phase liquid tank, where the liquid in the tank has a free surface, and the level of the surface is established by the use of an overflow weir. Furthermore, the overflow cascades into a reservoir adjacent to the tank. In another patent, JP '758 also describe an immersion tank for electronics, where the liquid has a free surface whose level is controlled by an overflow weir. In an immersion cooling system where accessibility to the electronics immersed in the fluid is important, it is advantageous to utilize a tank with a free, open upper surface. The use of an overflow weir is required in order to create a useable flow management technology, as illustrated by the embodiments described in these patents.

Temperature Measurement

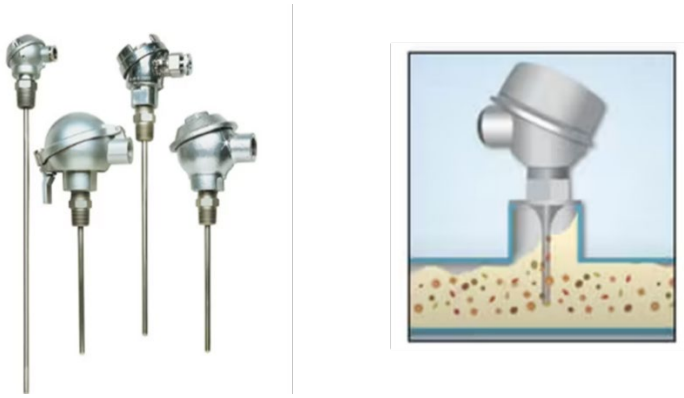
98. The measurement of temperature in thermal management systems is important for proper control of the system. Since the ultimate objective of any the thermal management system is to maintain the chip junction temperature at a desired level, formally called the thermal design point, TDP, it is important to be able to monitor the junction temperature as well as important attributes of the cooling system such as the flow rate and the coolant temperature. Thermal management control systems can set alarms, reduce system power, or shut down a system if temperatures exceed the TDP for an entire system or a sub-system.

Coolant Temperature

99. Temperatures of flowing fluids such as air or liquid are commonly measured with temperature sensors that are immersed into the flow. The most common type of sensor is a thermocouple. A thermocouple is constructed from a pair of dissimilar metal wires. On one end, the wires are joined to form a junction—that is the location that "measures" the temperature. On the other end, the pair of wires are connected to a voltmeter. If a temperature difference exists

between the junction end and the measurement end of a thermocouple, the thermocouple will self-generate a voltage that is proportional to the temperature difference. In industrial systems, thermocouples are placed inside metal tubes or sheaths to protect them from corrosion and other damaging effects of the fluids. Figure 16(a.) shows a typical rugged industrial thermocouple probe and 16(b.) shows a thermocouple probe inserted into a pipe with flow of a liquid.

100. There are other types of sensors that are used for temperature measurements of liquids including probes containing thermistors or resistance temperature devices (RTDs). These types of sensors use sensor materials whose electrical resistance is highly sensitive to temperature, hence measurement of the resistance of the sensor allows indirect measurement of temperature. More recently strap-on, non-intrusive temperature measurements have been developed that measure the temperature of the pipe that is in contact with the fluid. For measurement of the temperature of fluids in vessels or pipes, insertion probes as shown in Figure 8 are the most common approach.



(a.) (b.)

Figure 16. (a.) Thermocouple probes for temperature measurement in liquids; (b.) Thermocouple probe inserted into a pipe.[40]

Chip Junction Temperature

101. Measurement of the temperature on the circuit of a silicon chip cannot be performed by attaching a thermocouple or other such sensors to the physical circuit. The size of external sensors and the errors introduced by the poor contact between the sensor and the target surface prohibit their use. The common approach for chip junction temperature measurement is to use a temperature sensitive device that is directly integrated into the integrated circuit on the chip. The most common devices used for junction temperature measurement are diodes that are designed and fabricated as part of the integrated circuit.[41] Siegal (2009) states that "at low values of forward current (measurement or sense current), the junction temperature vs. forward voltage correlation

[40] *Industrial Thermocouples with Protection Head*, https://web.archive.org/web/20030131201627/http://www.omega.com/ppt/pptsc.asp?ref=NB1-ICIN_INDUST_TC&Nav=tema14 (archived January 3, 2003).

[41] Bernie Siegal, *An Introduction to Diode Thermal Measurements*, Thermal Engineering Associates, Inc. (2009), https://thermengr.net/An_Introduction_to_Diode_Thermal_Measurements6.pdf.

is nearly linear to the second order.[42] Thus, a change in junction temperature produces a corresponding change in junction forward voltage with a constant correlation factor of the form

$$\Delta T_j = K \times \Delta V_f \quad (7)$$

where K is called the K-factor and V_f is the forward bias voltage. When calibrated to obtain the K-factor, the correlation can be used to infer the junction temperature T_j by measuring the diode voltage. In modern electronic systems, it is common to design thermally sensitive devices such as a thermal diodes into integrated circuits to allow the measurement of the circuit temperature during operation.[43]

Overall Cooling Systems

102. Referring to Figure 5, a complete cooling system for the immersion tanks is required to transport the heated immersion coolant out of the immersion tanks, cool the fluid by rejecting heat to another medium, and returning the cool fluid back to the tanks. Figure 17. shows a schematic diagram of a typical liquid cooling system used in liquid cooling systems, including immersion cooling systems. In this cooling system, the secondary loop circulates the immersion cooling fluid, typically an electrically insulating oil, through the immersion tanks as shown in Figure 5. The system is designed to deliver the cooling fluid at a temperature that will keep the device junction temperature at the thermal design point. In Figure 17, the cold immersion fluid is delivered to the tanks through an inlet header that distributes the flow to the various tanks. As the fluid passes through the tank, it absorbs the dissipated heat from the electronics and thus heated coolant exits the various tanks through the outflow header. Closed loop systems such as this typically incorporate a tank to serve as a buffer, i.e. volume of fluid that can increase or decrease to absorb changes in the system while maintaining a constant flow rate. Leaving the buffer tank, the flow enters the pump.

103. The pump delivers the flow to a liquid-to-air heat exchanger which typically is a cooling tower as shown. In the cooling tower, the coolant liquid is circulated through piping with fins or extended surfaces to increase the surface area in contact with the air. Convection transfers heat from the water to the pipe and fins. Heat conduction transfers the heat through the fins to their surfaces. The air flow absorbs the heat from the fin surfaces by convection and then flows out of the heat exchanger and mixes with the environment air. As can be seen, the overall system absorbs heat from the electronic with the immersion tank coolant, and dissipates the heat to air.

104. The water to air heat exchangers are generally of two types. In traditional *wet cooling towers*, Figure 18(a.), water is used to absorb heat from the incoming air in order to pre-cool it

[42] *Id.*

[43] *See generally, e.g.*, U.S. Patent No. 8,283,876B2; Bernie Siegal & Mark Berg, *An Effective Alternative for Marginal Thermal Improvements of Semiconductor Devices*, Tenth IEEE Semi Therm Synposium 1994; Thomas S. Tarter & Bernie Siegal, *Application of thermal test chips to stacked chip packages*, 29th IEEE Semiconductor Thermal Measurement and Management Symposium Year: 2013 pp. 13-22; Bernie Siegal, *Practical Considerations in High Power LED Junction Temperature Measurements*, 2006 Thirty-First IEEE/CPMT International Electronics Manufacturing Technology Symposium, Petaling Jaya, Malaysia, 62-66 (2006).

before it is used to cool the primary water flowing through the finned piping. This is accomplished by causing water to evaporate into the air entering the cooling tower. Fans at the top of the cooling tower suck the air from the outside into the cooling tower. One method of evaporative cooling involves the use of wetted cellulosic honeycomb pads. Before entering the main finned heat exchanger section, the air is forced to flow through cellulosic honeycomb panels that are continuously wetted with external water. When the air passes through the honeycomb panels, water evaporates into the air and reduces its temperature. Evaporative cooling, also called adiabatic cooling, is effective in dry environments when the outside air temperature is too high to cool the primary water loop.

105. In cases when the outside air temperature is low, there is no need for additional evaporative cooling, and dry outside air is sucked into the cooling tower by the fans and it passes directly through the finned heat exchanger which is carrying the hot primary fluid, in this case water. These types of cooling towers are called “dry coolers,” Figure 18(b.). After passing through the dry cooler, the cool water enters the heat exchanger used to absorb heat from the secondary immersion cooling loop.

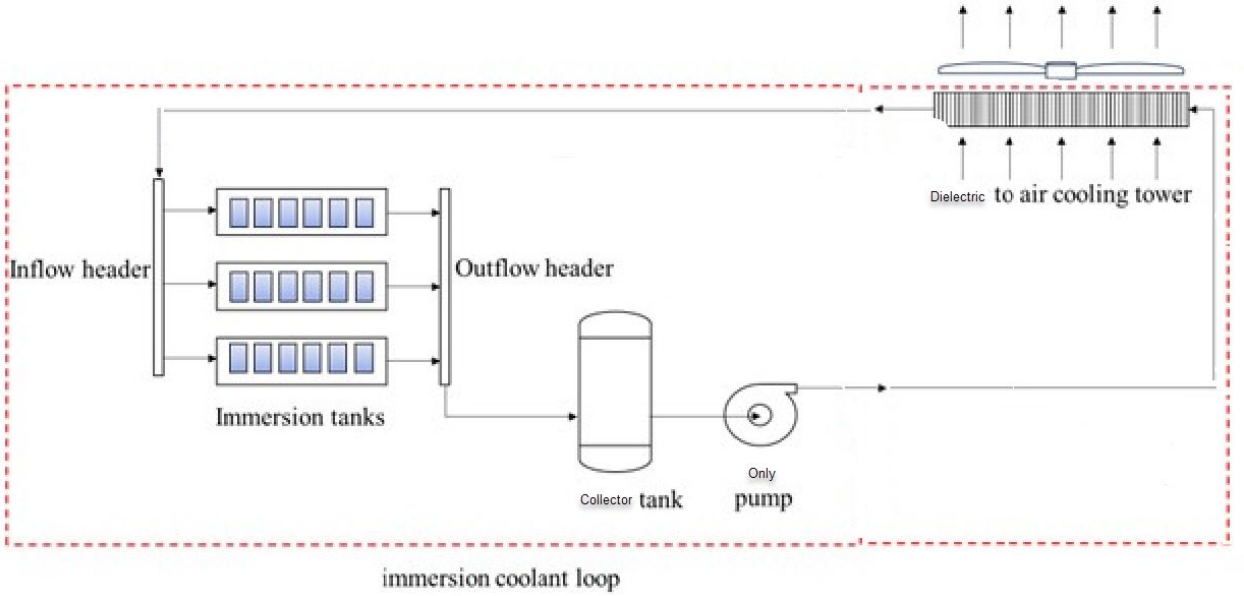
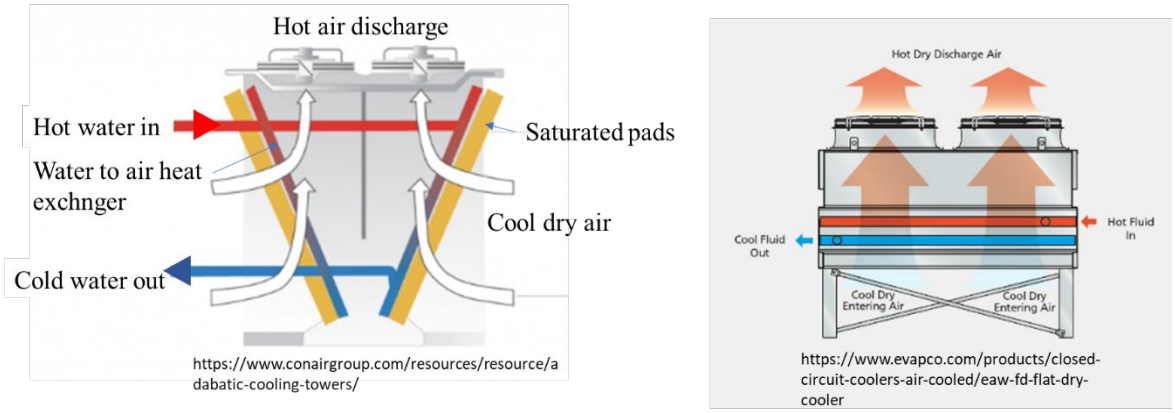


Figure 17. Overall cooling system to reject heat from immersion tanks to outside air.



(a.) (b.)

Figure 18. (a.) Wet cooling tower with evaporative cooling; (b.) Dry cooler.

DESCRIPTION OF THE ASSERTED PATENTS

The '457 Patent

Specification

106. The '457 patent is titled "Appliance Immersion Cooling System."[44] It was filed on December 13, 2013 as an international application under the Patent Cooperation Treaty ("PCT"), and claims the benefit of the filing dates of U.S. Provisional Patent Application No. 61/737,200, filed on December 14, 2012, and U.S. Provisional Patent Application No. 61/832,211, filed on June 7, 2013.[45]

107. The '457 patent names as inventors Christopher L. Boyd, James P. Koen, David Christopher Laguna, Thomas R. Turner, Kenneth D. Swinden, Mario Conti Garcia, and John Charles Tribou.[46] I understand that in March 2023, MGT submitted a Request for Correction of Inventorship in Patent Pursuant to 37 C.F.R. § 1.324(a), requesting that Christopher L. Boyd be named as the sole inventor of the '457 patent.[47] I further understand that the other named inventors have executed statements agreeing to the requested change of inventorship.[48]

108. The '457 patent claims a tank module and an appliance immersion cooling system for cooling electronic components submerged in a dielectric fluid.[49] It acknowledges that appliance immersion cooling systems that use a dielectric fluid to cool submerged electronic components

[44] '457 patent at [54].
[45] *Id.* at [22], 1:6-16, [60]; 2012 Provisional at MIDAS0004047; 2013 Provisional at MIDAS0004155.
[46] *Id.* at [72].
[47] Ex. 18 to J. Koen Dep., Dec. 5, 2023.
[48] Ex. 13 to M. Conti Dep., Sept. 14, 2023; Exs. 6, 8 to J. Tribou Dep., Sept. 13, 2023.
[49] *Id.* at 1:20-25, cls. 1, 6, 11.

exist within the prior art. It identifies several such prior art references; however, it asserts that there are problems with these prior art technologies.[50] For example, it identifies the advantages of the inventions disclosed in Cray '538 and Krajewski '511, but states that the vertical-stack-type system disclosed in these references necessitates draining the dielectric fluid whenever there is a need to access the electronic components and that the chosen dielectric fluid, fluorocarbon liquids, is costly and less effective at heat transfer than other dielectric fluids.[51]

109. It also acknowledges that there are prior art references that disclose solutions to these problems, specifically a web-presentation entitled "Puget Custom Computer's mineral-oil-cooled PC" by Nilay Patel ("Puget") and U.S. Patent Application Publication No. 2011/0132579,[52] the publication of Best '463.[53] Puget, the '457 patent states, implemented a design by which electronic components may be immersed vertically in a tank of dielectric mineral oil, thereby allowing withdrawal of the electronic components from the tank while the tank is operating.[54] Puget, however, did not include a secondary apparatus through which waste heat could be extracted from the dielectric fluid.[55]

110. The '457 patent states that Best '463 discloses the advantages of the other prior art references in addition to a secondary apparatus for extracting waste heat from the dielectric fluid, but exhibits the following problems: "generally non-uniform flow patterns through the several appliance slots within the tank, potentially resulting in uneven cooling across all slots; constricted dielectric fluid supply and return ports resulting in unnecessarily high fluid flow velocities at the respective points of connection to the tank; poor scalability; and inadequate attention to fail-soft operation."[56]

[50] *Id.* at 1:33-2:37.
[51] *Id.* at 1:33-1:65, 2:15-22.
[52] I understand that U.S. Patent Application Publication No. 2011/0132579 is the patent application that ultimately resulted in the issuance of U.S. Patent No. 10,123,463 to Best. I thus refer to both U.S. Patent Application Publication No. 2011/0132579 and U.S. Patent No. 10,123,463 as Best '463.
[53] *Id.* at 1:33-2:37.
[54] *Id.* at 2:2-14.
[55] *Id.* at 2:12-14.
[56] *Id.* at 2:23-37.

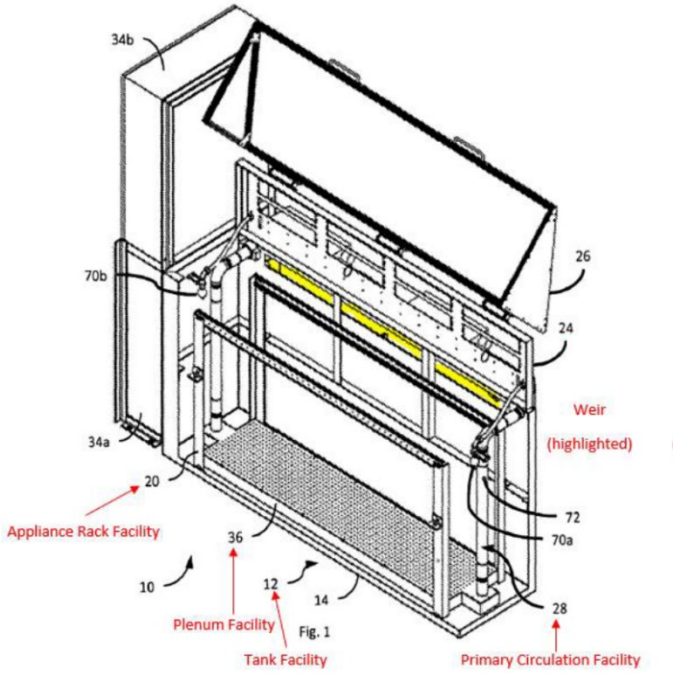


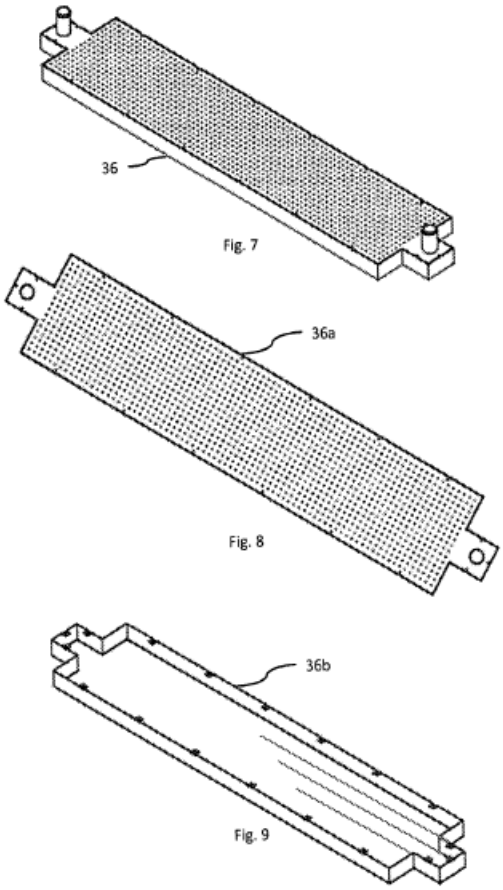
Figure 1 (annotated) illustrates, in partial cut-away form, a front perspective of a tank module of an appliance immersion cooling system according to the Asserted Patents.[57]

111. The '457 patent describes its invention as consisting of "fully redundant" components that are purportedly "adapted automatically to operate in a fail-soft mode":

> A appliance immersion tank system comprising: a generally rectangular tank adapted to immerse in a dielectric fluid a plurality of appliances, each in a respective appliance slot distributed vertically along, and extending transverse to, the long axis of the tank; a primary circulation facility adapted to circulate the dielectric fluid through the tank; a secondary fluid circulation facility adapted to extract heat from the dielectric fluid circulating in the primary circulation facility, and to dissipate to the environment the heat so extracted; and a control facility adapted to coordinate the operation of the primary and secondary fluid circulation facilities as a function of the temperature of the dielectric fluid in the tank. A plenum, positioned adjacent the bottom of the tank, is adapted to dispense the dielectric fluid substantially uniformly upwardly through each appliance slot. A weir, integrated horizontally into a long wall of the tank, is adapted to facilitate substantially uniform recovery of the dielectric fluid flowing through each appliance slot. All active and most passive components of both the primary and secondary fluid circulation facilities, and the control facility are fully redundant, and are adapted automatically to operate in a fail-soft mode.[58]

[57] *Id.* at Fig. 1.
[58] *Id.* at [57].

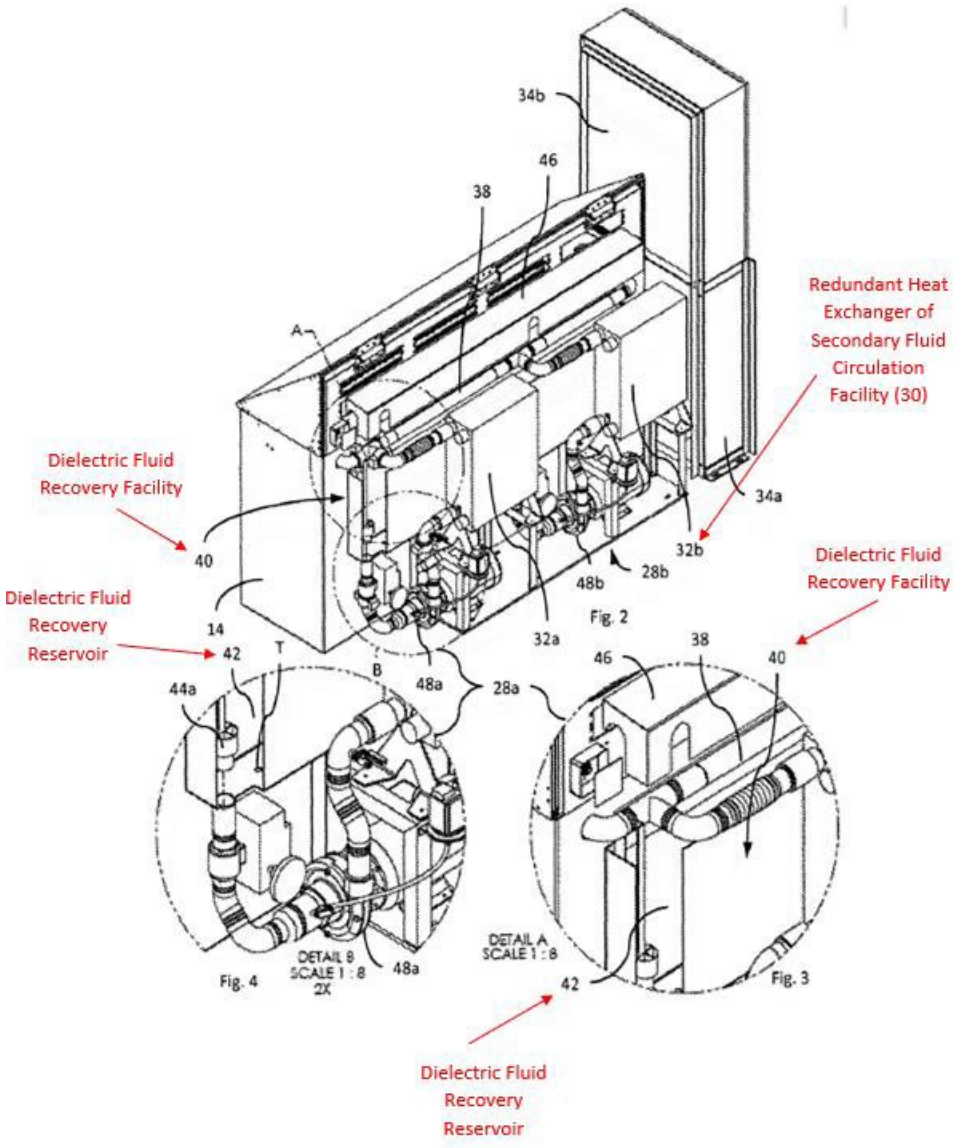
112. The '457 patent further describes the plenum, illustrated below, as comprising an orifice plate (FIG. 8) and a plenum chamber (FIG. 9). The plenum plate comprises at least one row of orifices vertically aligned with each appliance slot. The orifices purportedly ensure substantially uniform flow of the dielectric fluid upwardly into each appliance slot.[59] As discussed in the previous section on Flow Management, the presence of the perforated plate of itself does not ensure substantially uniform upward flow. In fact the method by which flow is introduced into the plenum chamber beneath the perforated plate, and the volume of the plenum chamber, are strongly coupled to the perforated plate. All three play an integral role in ensuring uniform flow.



Figures 7, **8**, and **9** illustrate in perspective view and top plan view, the plenum facility and the orifice plate and chamber portions of the plenum facility.

113. The '457 patent further describes that to extract heat from the dielectric fluid circulating in the primary circulation facility the secondary fluid circulation facility circulates a cooling fluid, distinct from the dielectric fluid, through heat exchangers, shown as 32a and 32b in the below illustration, as the dielectric fluid counter-circulates through the heat exchangers. The secondary fluid circulation facility is also comprised of conventional cooling towers that include fan facilities.[60]

[59] *Id.* at 4:11-26.
[60] *Id.* at 4:66-5:9.



Figures 2, **3**, **and 4** (annotated) illustrate a rear perspective of the "tank module."[61]

114. The '457 patent further describes a primary controller adapted to monitor and control the operation of the primary circulation facility as a function of the temperature of the dielectric fluid in the tank; a secondary controller adapted to monitor and control the operation of the secondary fluid circulation as a function of the temperature of the dielectric fluid flowing through the heat exchanger; and a master controller adapted to coordinate the activities of the primary controller and secondary controller.[62]

115. The '457 patent describes the 2012 Provisional as "an alternate embodiment comprising an appliance immersion tank facility wherein the function of the plenum facility [] is performed by a manifold facility comprising a ladder-arrangement of tubular spray bars, each bar of which

[61] *Id.* at Figs. 2-4.
[62] *Id.* at 5:25-41.

supplies dielectric fluid to a respective appliance slot."[63] It states that the disclosure further includes an enhancement, "temperature sensors per appliance slot, such that the flow rate through each spray bar can be dynamically varied as a function of the temperature of the dielectric fluid exiting the respective slot." And it describes the 2013 Provisional as "another embodiment comprising a more conventional, less-modularized instantiation with appropriate flow and control facilities."[64] Temperature sensors by each appliance slot further allow for control of the dielectric liquid flow rate as a function of the temperature of the dielectric fluid exiting the appliance slot.[65]

Prosecution History

116. I understand that the '457 Patent issued from U.S. Application Ser. No. 14/355,533. During prosecution, an examiner from the PTO issued the first of three office actions, a non-final rejection, on November 4, 2016.[66] The then pending application consisted of ten claims. The examiner rejected then pending dependent claim 2 and 7, which recited a "tightly co-located module," as indefinite.[67] The examiner also rejected all pending claims as anticipated by Best '463 or obvious over Best '463 in view of Pfahnl '292. The examiner explained that Best '463 teaches every limitation of the then pending claims, as follows:

> a tank (e.g. 610, 710, 810) adapted to immerse (622, 722, 822) in a dielectric fluid (Para. [0025]) a plurality of electrical appliances (120), each in a respective appliance slot (Figs. 4, 6, 11) distributed vertically along, and extending transverse to, a long wall of the tank (L; e.g. Figs. 3-4), the tank comprising:
>
> a weir, integrated horizontally into the long wall of the tank adjacent all appliance slots, adapted to facilitate substantially uniform recovery of the dielectric fluid flowing through each appliance slot (Para. [0102]; the "common manifold area" defined by the tops of the slots and the devices 120, 820);[68]
>
> a primary circulation facility adapted to circulate the dielectric fluid through the tank (see 440/450, 540/550, etc.), comprising:
>
> a plenum, positioned adjacent the bottom of the tank, adapted to dispense the dielectric fluid substantially uniformly upwardly through each appliance slot (Para. [0086]; Figs. 5-6; HL);[69]
>
> a secondary fluid circulation facility adapted to extract heat from the dielectric fluid circulating in the primary circulation facility, and to dissipate to the environment the heat so extracted (150; 250; 350); and

[63] *Id.* at 6:37-42.
[64] *Id.* at 7:28-31.
[65] *Id.* at 6:49-53.
[66] '457 Patent Prosecution History, MIDAS0003334 at -3495-501.
[67] *Id.* at MIDAS0003497.
[68] *Id.* at MIDAS0003498.
[69] *Id.* at MIDAS0003498.

a control facility adapted to coordinate the operation of the primary and secondary fluid circulation facilities as a function of the temperature of the dielectric fluid in the tank (380, 370; Fig. 2, "temp data").[70]

117. The examiner further provided that to the extent Best '463 does not teach a weir and plenum, Pfahnl '292 also teaches a plenum (inlet plenum) and a weir (outlet plenum).[71]

118. On January 31, 2017, the patent applicant traversed the examiner's rejection. The applicant amended the pending claims to describe the weir as "having an overflow lip."[72] In addition, it argued that the patent specification outlines that the purpose of the phrase "tightly co-located" is "to characterize the essential components of the primary circulation facility as being physically located sufficiently close to the tank" and "to "move the secondary fluid to the point of heat exchange with the primary fluid, rather than to move the primary fluid to the point of exchange with the secondary fluid."[73]

119. The applicant also argued that Best '463 does not teach either a weir or a plenum because in Best '463 these structures are only present when the tank is full of fluid, whereas the then pending claims require that these structures be physically present even when the tank is empty of fluid.[74] It further argued that the outlet plenum disclosed in Pfahnl '292 does not satisfy the claim term weir:

> In contrast, in Pfahnl, each of the openings 122 into the plenum 112 is disposed adjacent only to a respective single ONE of the appliance slots, and none is disposed adjacent to ALL of the appliance slots. Further, the rate of air flow through each of the openings 122 into the [outlet] plenum 112 is NOT substantially uniform since the outlet port 112a itself does not lie adjacent to each of the openings 122. It follows, therefore, that the function performed by the set of openings 122 into the [outlet] plenum 112 is **not** equivalent to the function performed by Applicants' weir. In an effort to further distinguish Applicants' weir from the plenum structure in Pfanhl, Applicants have amended claims 1 and 6 to emphasize that it is the "overflow lip" of the weir that is "adapted to facilitate substantially uniform recovery of the dielectric fluid flowing through each appliance slot."[75]

120. On May 17, 2017, the examiner issued a final rejection of the then pending claims as obvious over Best '463 and Pfahnl '292, identifying the heated liquid coolant outlet and the bottom

[70] *Id.* at MIDAS0003500.
[71] *Id.* at MIDAS0003499.
[72] *Id.* at MIDAS0003483-3486.
[73] *Id.* at MIDAS0003487.
[74] *Id.* at MIDAS0003487.
[75] *Id.* at MIDAS0003487-3488 (emphasis in original).

lip of the opening thereof (Fig. 14) disclosed by Best '463 as satisfying the weir and overflow lip limitations.[76]

121. On August 24, 2017, the applicant amended the claims to recite, "a dielectric fluid recovery reservoir positioned vertically beneath the overflow lip of the weir and adapted smoothly to receive the dielectric fluid as it flows over the weir," and added claims 11 to 16, which match claims in European Patent Application No. 13870761.7 that were allowed by the European Patent Office.[77] The applicant also traversed the examiner's rejection, arguing that the physics of the then pending claims and Pfahnl '292 are not the same.[78] The applicant further argued, quoting the EPO's reasoning for allowing claims 11 to 16, that in Best '463 because the supply of the cooling fluid is on one side wall of the tank and the return is through a pipe on the same or the other side of the tank, most of the cooling fluid flows in the most direct path between the inlet and the outlet risking pockets of stagnant fluid off that path.[79]

122. On December 5, 2017, the examiner issued a notice of abandonment due to the applicant's failure to file a Notice of Appeal or Request for Continued Examination after the final rejection.[80] The applicant filed a Petition for Revival and Request for Continued Examination on January 7, 2018, which the PTO granted on May 9, 2018.[81]

123. On June 11, 2018, the examiner issued a non-final rejection. The examiner rejected claims 1-10 as indefinite due to the phrase, "adapted smoothly," and claims 1-16 as obvious over Best '463 in view of JP 5956100 ("JP '100"). The examiner explained that Best '463 does not disclose a weir with a recovery reservoir, but JP '100 teaches these elements.[82]

124. On September 14, 2018, the examiner issue a Notice of Allowance.[83] The notice included an amendment by the examiner, who deleted the word, "smoothly' from the claims based on a voicemail from the applicant.[84] The examiner also noted as reasons for allowance that JP '100 does not qualify as prior art as it was published after the effective filing date of the application.[85] The '457 patent issued on September 3, 2019.[86]

Post Grant Proceedings

125. On June 23, 2021, Immersion Systems LLC filed a petition for *Inter Partes* Review ("IPR") of claims 1, 5, 6, 10, 11, and 14 of the '457 patent on the following obviousness grounds: (1) Best '463 in view of Krajewski '511 and/or Cray '538 (2) Best '463 in view of Oktay '244; (3)

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[76] *Id.* at MIDAS0003473-3479.
[77] *Id.* at MIDAS0003434-3440.
[78] *Id.* at MIDAS0003440.
[79] *Id.* at MIDAS0003440-3441.
[80] *Id.* at MIDAS0003425-3426.
[81] *Id.* at MIDAS0003391-3392, -3394-3395, -3383-3386.
[82] *Id.* at MIDAS0003371-3381.
[83] *Id.* at MIDAS0003356-3363
[84] *Id.* at MIDAS0003362.
[85] *Id.* at MIDAS0003362.
[86] *Id.* at MIDAS0003334; '457 patent at [45].

Best '463 in view of Gryzhin '013; and (4) Best '463 in combination with the knowledge of a POSA. Immersion Systems also submitted a declaration by Dr. Issam Mudawar in support of the petition. MGT filed a Patent Owner Preliminary Response to Petition on October 14, 2021. Immersion Systems filed a Reply on November 19, 2021, to which MGT filed a Sur-Reply on November 29, 2021.[87] I have reviewed this material, and have incorporated information from them in my analysis.

126. On January 6, 2022, the Patent Trial and Appeal Board, in its discretion, denied the petition for review.[88]

The '446 Patent

Specification

127. The '446 patent is a continuation of, and has the same specification as, the '457 patent.[89] It was filed on January 9, 2019, and claims the benefit of the filing date of the 2013 Provisional.[90] It names as inventors Christopher L. Boyd, James P. Koen, David Christopher Laguna, Thomas R. Turner, Kenneth D. Swinden, Mario Conti Garcia, and John Charles Tribou.[91] However, I understand that on March 21, 2023, MGT submitted a Request for Correction of Inventorship in Patent Pursuant to 37 C.F.R. § 1.324(a), requesting that Christopher L. Boyd be named as the sole inventor of the '446 patent.[92] I further understand that the other named inventors have executed statements agreeing to the requested change of inventorship.[93]

128. The '446 patent claims a tank module and an appliance immersion cooling system for cooling electronic components submerged in a dielectric fluid.[94] Unlike the '457 patent, the '446 patent does not claim "an overflow lip adapted to facilitate substantially uniform recovery of the dielectric fluid flowing through each appliance slot" or "a dielectric fluid recovery reservoir positioned vertically beneath the overflow lip of the weir and adapted to receive the dielectric fluid as it flows over the weir."[95]

[87] *Immersion Systems LLC v. Midas Green Technologies, LLC*, No. IPR2021-01176 (P.T.A.B. June 23, 2021).
[88] Decision Denying Institution of *Inter Partes* Review, *Immersion Systems LLC v. Midas Green Technologies, LLC*, No. IPR2021-01176 (P.T.A.B. January 6, 2021).
[89] '446 patent at [63].
[90] *Id.*
[91] *Id.* at [72].
[92] Exs. 5, 7 to J. Tribou Dep., Sept. 13, 2023.
[93] Exs. 6, 8 to J. Tribou Dep., Sept. 13, 2023.
[94] '446 patent at 1:20-25, cls. 1, 6.
[95] *Id.*

Prosecution History

129. The examiner issued a single rejection during prosecution of the '466 patent: a non-final nonstatutory double patenting rejection on April 13,2020.[96] The examiner issued a notice of allowance on April 16, 2020,[97] and the '446 patent issued on October 27, 2020.[98]

130. I understand that on October 11, 2021 and November 12, 2021, MGT filed requests for a certificate of correction of the '446 patent's "Related U.S. Application Data" section in order to claim the benefit of the priority date of the 2012 Provisional. I understand that the PTO published a certificate of correction on December 14, 2021, but then vacated the correction on December 24, 2021. As such, I understand that the claimed purported effective filing date of the '446 patent is June 7, 2013, the filing date of the 2013 Provisional.[99]

Post Grant Proceedings

131. On July 26, 2021, Immersion Systems LLC filed a petition for Post Grant Review ("PGR") of claims 1, 5, 6, and 10 of the '446 patent on the following obviousness grounds: (1) Best '463 in view of Krajewski '511 and/or Cray '538 (2) Best '463 in view of Oktay '244; (3) Best '463 in view of Gryzhin '013; and (4) Best '463 in combination with the knowledge of a POSA. Immersion Systems also submitted a declaration by Dr. Issam Mudawar in support of the petition. MGT filed a Patent Owner Preliminary Response to Petition on November 3, 2021 and November 12, 2021. Immersion Systems filed a Replies on November 23, 2021 and December 3, 2021, to which MGT filed Sur-Replies on November 29, 2021 and December 13, 2021.[100] I have reviewed this material, and have incorporated information from them in my analysis.

132. On January 31, 2022, the Patent Trial and Appeal Board, in its discretion, denied the petition for review.[101]

SUMMARY OF PRIOR ART

Best '463

133. Best '463 is titled "Liquid Submerged, Horizontal Computer Server Rack and Systems and Method of Cooling Such a Server Rack," and "provides novel apparatus, systems, and methods for efficiently cooling computing devices having heat-generating electronic components, such as, for example, independently operable servers immersed in a dielectric liquid coolant in a tank."[102] It teaches a system that includes (1) at least one tank, having a coolant inlet and a coolant outlet;

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[96] '446 Patent Prosecution History, MIDAS0003913 at MIDAS0003937-3941.
[97] *Id.* at MIDAS0003926-3930.
[98] *Id.* at MIDAS0003913; '446 patent at [45].
[99] '446 patent at [63], [60].
[100] *Immersion Systems LLC v. Midas Green Technologies, LLC*, PGR2021-00104 (PTAB July 26, 2021).
[101] Decision Denying Institution of Post-Grant Review, *Immersion Systems LLC v. Midas Green Technologies, LLC*, PGR2021-00104 (P.T.A.B. January 31, 2022).
[102] Best '463 at [54], 4:31-35.

(2) one or more mounting members; (3) a dielectric liquid coolant; (4) a heat exchanger; (5) a pump; and (6) a controller.[103]

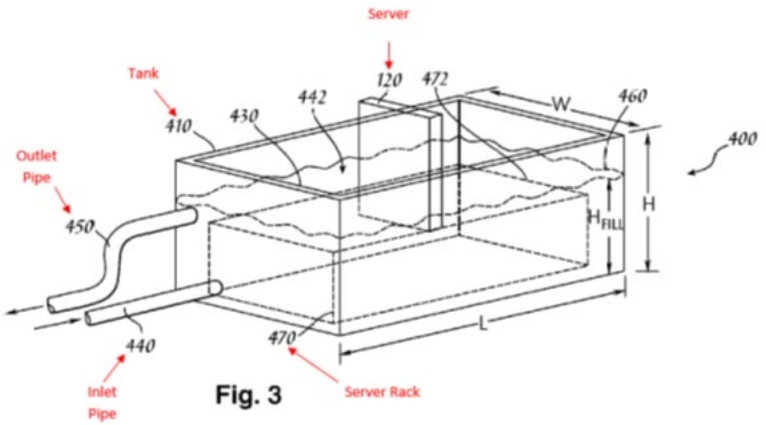


Fig. 3

Figure 3 (annotated) illustrates one embodiment of the system of Best '463.

134. The tank contains in its interior volume the dielectric liquid coolant and the mounting members. The mounting members are configured to receive each of a plurality of independently operable servers.[104] Best '463 describes mounting the servers for cooling within the tank "wherein, the mounting members are configured to hold each of at least two of the rack mountable servers in the at least one row in a horizontally stacked relationship with one-another, with the rack mountable servers in a vertical orientation."[105] Best '463 identifies that the "vertical orientation" of the servers "minimiz[es] the footprint of the servers relative to the ground" and facilitates "easy installation and removal of a server without the need to remove or disturb any other server within the tank 810."[106] The "servers in a vertical orientation" is illustrated below:

[103] *See id.* at 4:36-6:2.
[104] *Id.* at 4:36-44; 5:3-7.
[105] *Id.* at cl. 1, 26:11-20.
[106] *Id.* at 18:65-19:4.

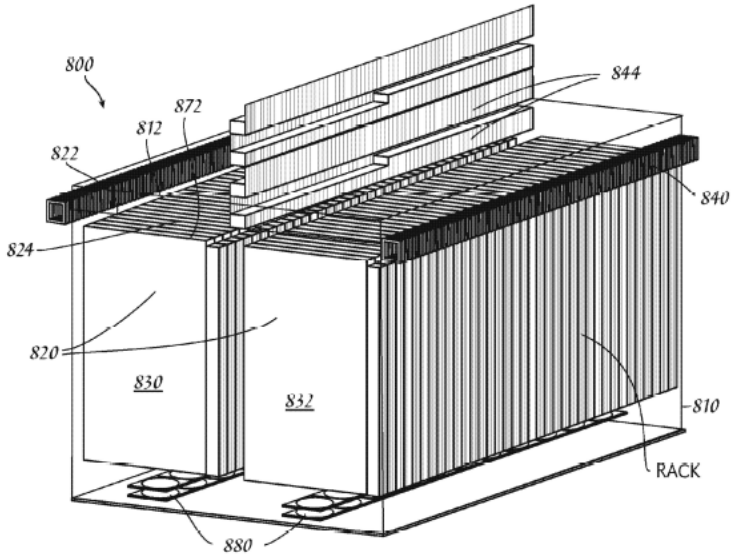


Fig. 11

Figure 11 illustrates a perspective view of one embodiment of Best '463.

135. The tank possesses a coolant inlet and a coolant outlet. Best '463 describes the tank to "have an inlet pipe or line 440 from a piping system connected to a heat exchanger for the flow of lower temperature or cooled liquid coolant into the tank 410 and an outlet pipe or line 450 connected to collection piping for flowing or pumping of heated coolant out of the tank to the external heat exchanger."[107] The inlet and outlet piping in Best '463 is illustrated below:

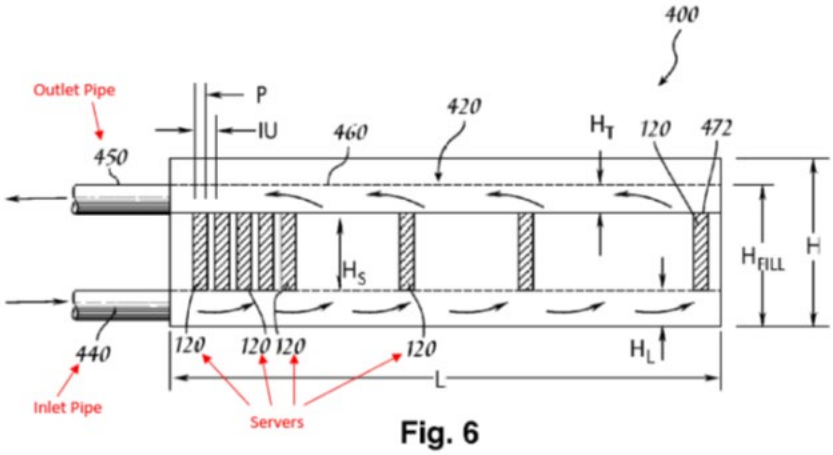


Fig. 6

Figure 6 (annotated) illustrates a side elevation view one embodiment of Best '463.

136. "Similar to FIGS. 3 thru 6, the inlet piping may be located at one end of the rectangular tank 810 near the bottom of the tank; whereas the outlet piping may be located nearer the top of the tank. This configuration permits the liquid coolant heated by the heat generating components in the servers to naturally rise through the servers and exit through the front panel of the servers."

[107] Best '463 at 14:40-45.

In an alternate embodiments "the outlet piping 650 is located nearer the opposite end of the same longer side of the rectangular tank nearer the top of the tank."[108]

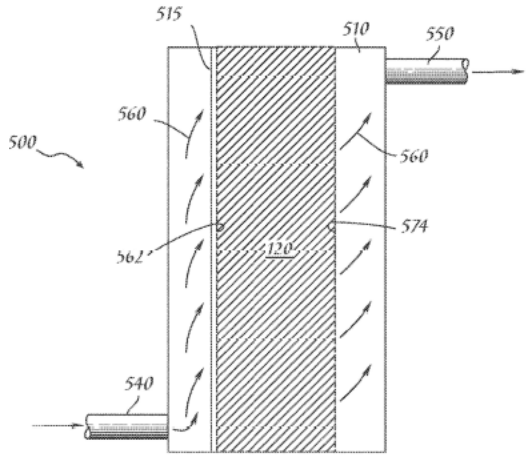


Fig. 8

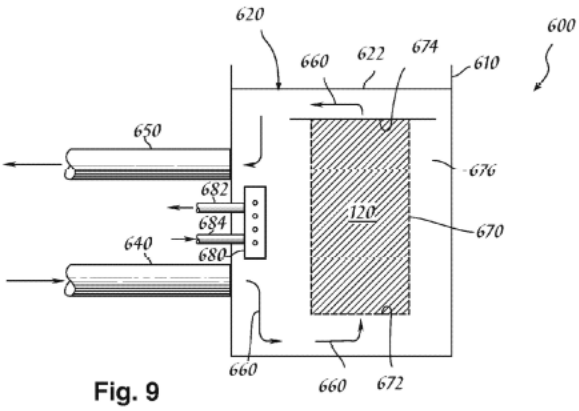


Fig. 9

Figures 8 and **9** illustrate a top plan view and an elevation view of one embodiment of Best '463.

137. Best '463 identifies there to be uniform temperature of the fluid, as "the liquid coolant may flow through each installed server and exit through the outlet pipe from the tank" and "[b]ecause the flow is relatively low in comparison to the total volume of the container, the fluid conducts to be relatively uniform temperature."[109] Ultimately, Best '463 identifies that "a volume of liquid coolant collects in a common manifold area above the server rack []to improve the circulation of the liquid coolant through the plurality of servers, thereby enhancing the cooling of each respective server."[110]

138. Best '463 describes that the mounting members within the tank "may also be configured to mount the servers in a server rack above the bottom of the tank to create a volume of liquid coolant between each respective server and the bottom of the tank such that the flow of the dielectric liquid coolant through the servers is improved."[111] In its preferred embodiment, Best '463 identifies that "the mounting members are configured to mount the servers closely adjacent to one another in the server rack to restrict flow of the dielectric liquid coolant between the vertically-oriented servers, such that the flow of the dielectric liquid coolant through the servers is enhanced."[112]

139. Best '463 describes the configuration of the tank to "permit the liquid coolant heated by the heat generating components in the servers to naturally rise through the servers and exit through

[108] *Id.* at 16:26-29.
[109] *Id.* at 19:36- 47.
[110] *Id.* at 14:61-64.
[111] *Id.* at 14:65-15:3.
[112] *Id.* at 15:3-8.

the top or "front panel" of the servers."[113] The naturally rising flow of Best '463 through the servers can be seen in Figure 6 above.

140. Best '463 describes multiple embodiments for cooling a plurality of servers. For example, "FIG. 1A illustrates one embodiment of an exemplary system for efficiently cooling a plurality of independently operable servers" and "FIG. 1B illustrates an alternative embodiment of an exemplary system for efficiently cooling a plurality of independently operable servers."[114]

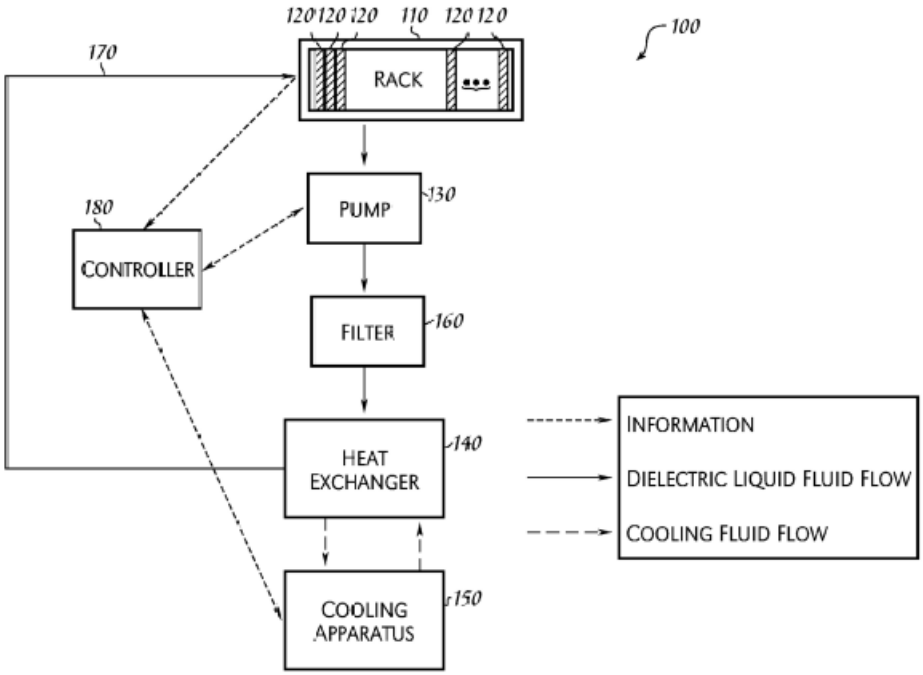


Fig. 1A

[113] *Id.* at 15:17-20.
[114] *Id.* at 7:26-32.

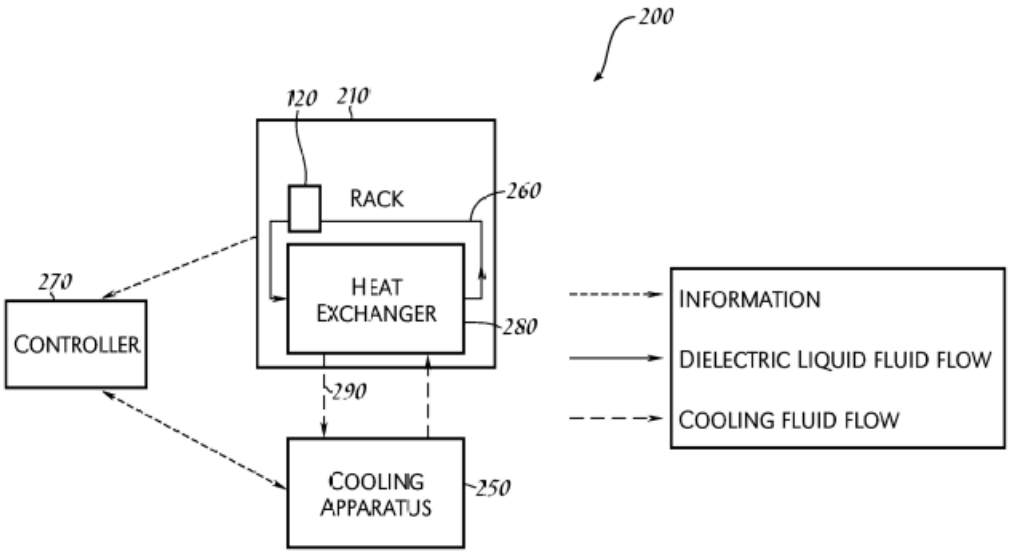


Fig. 1B

Figures 1A and **1B** illustrate embodiments of Best '463.

141. Additionally, Best '463 describes an embodiment wherein "a secondary cooling system having a cooling fluid flowing in a second fluid circuit wherein the secondary cooling system rejects heat from the cooling fluid."[115]

142. Best '463 describes controlling the operation and flow of the fluid within the system via a controller.[116] Best '463 discloses a computer controller that may receive monitor signals of various operational parameters from various components of the cooling system and may generate control signals to control various components of the cooling system to maintain the heated liquid coolant exiting the servers in the tank at a specific elevated temperature. Particularly, the controller 180 monitors the temperature of the liquid coolant at at least one location within the fluid circuit, for example where the heated liquid circuit exits the plurality of servers. The controller 180 may also monitor the temperature of the heat-generating electronic components in the servers in the server racks by electrically connecting the controller 180 to the diagnostic output signals generated by conventional rack-mountable servers.[117] The controller may also monitor the flow of the dielectric liquid coolant. Based upon such information, the controller 180 may output signals to the pump 130 and heat rejection or cooling apparatus 150 to adjust the flow of the liquid coolant through the fluid circuit and the amount of the heat being rejected by the heat rejection or cooling apparatus 150 for sufficiently cooling each respective server while maintaining the heated liquid

[115] *Id.* at 5:9-11.
[116] *Id.* at 4:56-58.
[117] *Id.* at 10:54-11:5.

coolant exiting the servers at the elevated temperature to reduce the amount of energy consumed to sufficiently cool each of the servers in the server rack.[118]

143. Finally, Best '463 contemplates being able to remotely control the system as "fluid valve 390 may be remotely controlled to connect the heated liquid coolant being pumped through the collection piping from tank 310 to a controller-selected one of alternative remotely or distally located heat exchangers."[119] The controller and its software in Best '463 is illustrated below:

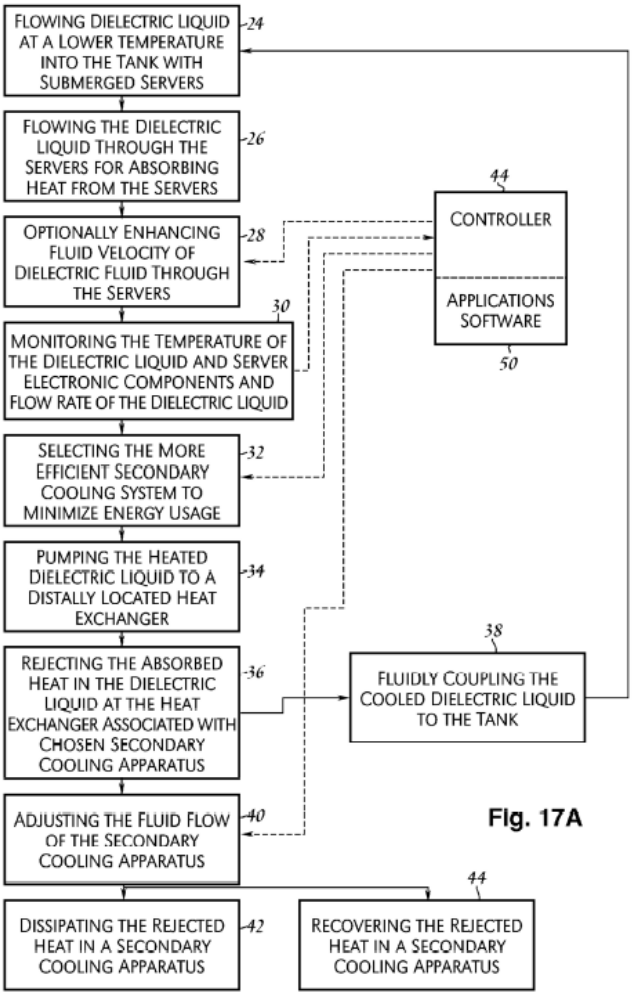


Fig. 17A

Figure 17A illustrates the steps in the method of immersion cooling in Best '463.

144. Best '463 was filed under the Patent Cooperation Treaty on August 10, 2009, and was published on February 18, 2010.[120] I understand that Best '463 thus qualifies as prior art to the Asserted Patents under at least 35 U.S.C. § 102(b) (pre-AIA) and 35 U.S.C. § 102(a)(1) (AIA).

[118] *Id.* at 10:44-54.
[119] *Id.* at 13:25-29.
[120] *Id.* at [22], [87].

Best '914

145. Best '914 is a continuation of Best '463, and was described in a printed publication on February 18, 2010.[121] I understand that Best '914 therefore qualifies as prior art to the Asserted Patents under at least 35 U.S.C. § 102(b) (pre-AIA) and 35 U.S.C. § 102(a)(1) (AIA).

Best Publication

146. The Best Publication, titled Hard Drive Cooling For Fluid Submersion Cooling Systems, discloses a system for cooling hard disk drives ("HDDs") and computing systems by submerging the computing systems in a tank of dielectric liquid coolant and by thermally coupling the HDDs to a heat conductive extension that is partly submerged into the coolant and partly out of the coolant. The HDDs are mounted to the part of the heat conductive extension that is out of the coolant, and are cooled through conduction of the heat from the HDDs to the coolant via the heat conductive extension.[122] The system may further use a heat exchanger to cool the dielectric liquid coolant in the tank,[123] and a controller may be used to maintain the dielectric liquid coolant at substantially a specific elevated temperature.[124]

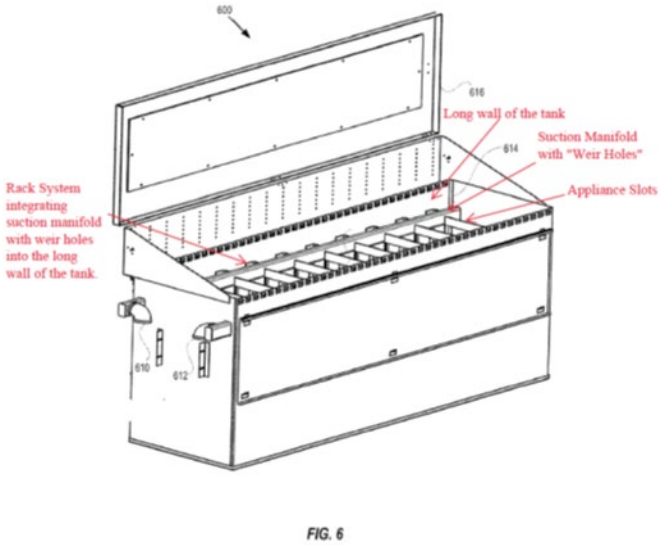


Figure 6 (annotated) depicts an exemplary tank in Best Publication.

147. The Best Publication teaches that in an embodiment, the tank includes a suction manifold 720 and a pressure manifold 710. The pressure manifold is attached to a coolant inlet 612 and the suction manifold is attached to a coolant outlet 610. The coolant inlet and the coolant outlet may be located on same or different sides of the tank. Both the suction manifold and the pressure manifold have a plurality of nozzles distributed along their length.[125]

[121] Best '463 at [87].
[122] Best Publication at [54], [57], [0018].
[123] *Id.* at [0019].
[124] *Id.* at [0021].
[125] *Id.* at [0068]-[0071].

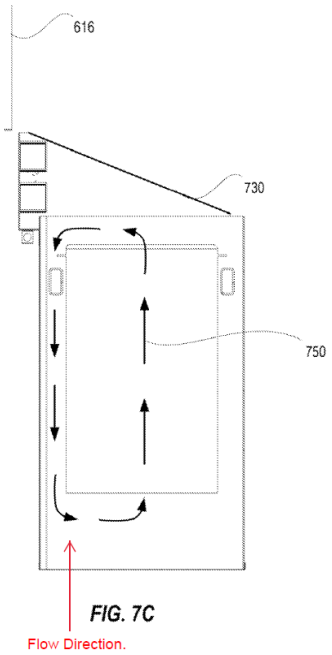


Figure 7C (annotated) is a left side view of the exemplary tank in Best Publication.

148. The above illustration shows one possible flow direction of the dielectric liquid coolant in the tank. Dielectric liquid coolant heated by the computing systems 230 and HDDs 240 is fluidly coupled through suitable piping or lines to a pump 212. The pump 212 pumps the heated liquid coolant through suitable piping or lines to a heat exchanger 216, which is associated with a heat-rejection or cooling apparatus 218.[126] The Best Publication also teaches a secondary cooling apparatus that contains a second cooling fluid and forms a second fluid circuit. The secondary cooling apparatus 218 includes an associated heat exchanger that may be local or remote to the system 200 to reject heat from the cooling fluid in the second fluid circuit through the second heat exchanger. The heat rejected from the heated cooling fluid in the second fluid circuit may then be selectively dissipated.[127]

149. The Best Publication also teaches a controller to maintain the heated liquid coolant exiting the computing systems in the tank 210 at a specific temperature. The controller 270 monitors the temperature of the liquid coolant at a location within the internal fluid circuit. The controller 270 may also monitor the temperature of the heat-generating electronic components in the computing systems 230 and HDDs 240 by electrically connecting the controller to the diagnostic output signals generated by conventional rack-mountable computing systems.[128]

150. I understand that Best Publication claims priority to Provisional Application No. 61/574,601, filed on August 5, 2011 ("Best Publication Provisional").[129] The Best Publication

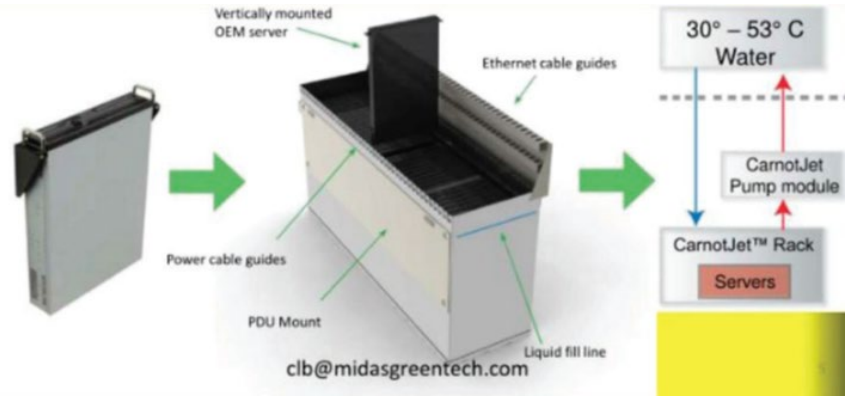
[126] *Id.* at [0053]-[0055].
[127] *Id.* at [0060].
[128] *Id.* at [0062].
[129] *Id.* at [60].

Provisional is titled "Hard Drive Encasement and Heat Transfer for Fluid Submersion Systems." It incorporates by reference U.S. Patent Application No. 13/057,881, which became Best '463.[130] It describes a tank with side mounted ears that sit on a mounting manifold inside the tank. Heat generating electronic components, including "Motherboard (and included components) and the Power Supply, which are mounted to the frame, are submerged "beneath the coolant (liquid) line" of the tank. The Best Publication Provisional also contains drawings that correspond to Figures 3, 5A, and 5B of the Best Publication. Because the Best Publication Provisional incorporates Best '463, it also discloses, among other things, "nozzles mounted on the end of a line from the cooling inlet piping which may be directed toward the desired entry point of the liquid coolant into the servers to enhance the fluid velocity of the liquid coolant through the servers," "an outlet pipe or line 450 connected to collection piping for the flowing or pumping of heated coolant out of the tank to the external heat exchanger associated with one or more of the heat-rejection or cooling systems," and "a controller for monitoring the temperature of the dielectric liquid coolant."[131] It is thus my opinion that the Best Publication Provisional contains written description of and describes how to make and use the invention claimed in the Best Publication.

151. Best Publication was filed under the Patent Cooperation Treaty on August 4, 2012. I understand that the Best Publication therefore qualifies as prior art to the '457 and '446 patents under at least 35 U.S.C. § 102(e) (pre-AIA) and 35 U.S.C. § 102(a)(2) (AIA).

Best Tank

152. The Green Revolution Cooling tank invented by Christiaan Best (the "Best Tank") was sold to MGT in 2010 and to Texas Advanced Computing Center in 2010. I understand that the Best Tank embodies the Best Publication.[132]



Depiction of Best Tank (CarnotJet 42U Rack).[133]

[130] *See* U.S. Provisional Patent Application No. 61/574,601.
[131] *See id.*
[132] *See* Declaration of Christiaan Best ("Best Decl.") ¶¶ 2, 6-9; Boyd Dep. 219:11-18; 220:14-222:23, Dec. 7, 2023; Pl.'s Supp. Resp. to Defs.' Interrog. No. 13, Mar. 15, 2023 at 5; *see also* Pl.'s Supp. Resp. to Defs.' Interrog. No. 13, Apr. 5, 2023 at 7; Pl.'s Resp. to Defs.' Req. Admis. No. 3, Aug. 31, 2022; TACC00000065; RHOD0000907; RHOD0000801; RHOD0000813.
[133] *See, e.g.*, RHOD0001042.

153. I understand that the Best Tank therefore qualifies as prior art to the Asserted Patents under at least 35 U.S.C. § 102(b) (pre-AIA) and 35 U.S.C. § 102(a)(1) (AIA).

Oktay '244

154. Oktay '244, titled Multi-Liquid Heat Transfer, discloses a heat transfer apparatus for cooling heat generating electronic devices by immersing the electronic devices in a dielectric liquid that has a low temperature boiling point.[134] A second liquid that has a higher boiling point than the dielectric liquid is superimposed on the free surface of the dielectric liquid. The second liquid is maintained at a predetermined temperature using a heat exchanger. The dielectric liquid boils at atmospheric pressure slightly above ambient room temperature. When the dielectric liquid is heated, bubbles form and condense at the interface between the liquids.[135]

155. Oktay '244 describes certain difficulties which led to the claimed invention. For example, Oktay '244 identifies that "electronic solid-state computer applications" may not be "desired to operate with a high pressure cooling system since lead sealing, general leakage and non-accessibility present problems and undesired arrangement."[136]

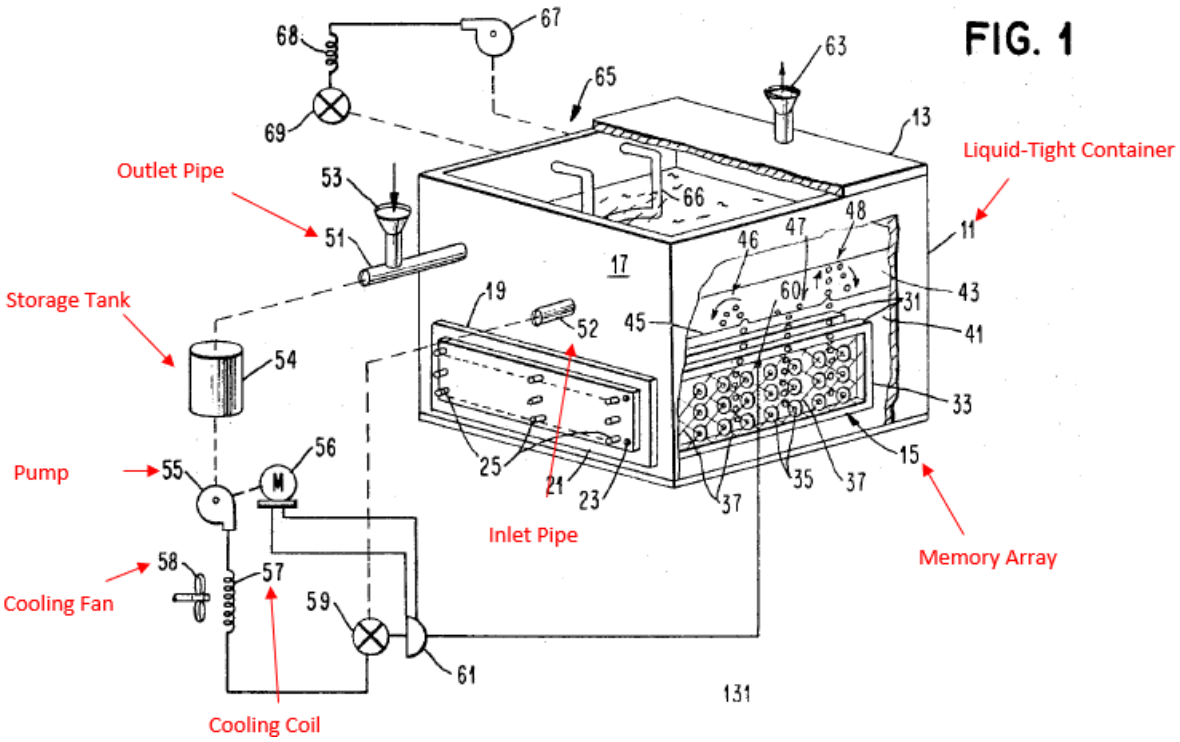


Figure 1 (annotated) is a broken-away perspective view of an embodiment of Oktay '244.

[134] Oktay '244, 1:10-23, 64-70.
[135] *Id.* at 1:71-2:15.
[136] *Id.* at 1:44-47.

156. Oktay '244 describes "[i]n FIG. 1 a liquid-tight container 11 has a slip-on cover 13 and a memory array 15 located therein which is electrically connected through a wall 17 of the container."[137] A memory array (15) is immersed in a dielectric liquid inside the container.[138] Oktay '244 identifies that the "means for cooling the upper, condensing liquid 43 includes an outlet pipe 51 and an inlet pipe 52, both extending through a side wall of the container 11. The outlet pipe has a make-up funnel 53 and connects to a storage tank 54."[139] Further, "a pump 55 having motor 56 receives liquid from the tank and pumps it through a cooling coil 57, which has fan 58 for cooling, to a thermostatically controlled valve 59."[140]

157. The outlet pipe connects to a storage tank (54). A pump (55) receives liquid from the storage tank and pumps it through a cooling coil (57) that has a fan (58) for cooling the liquid to a thermostatically controlled valve (59). A temperature sensor (60) for the thermostatically controlled valve is mounted near the top of the memory array.[141] The thermostatically controlled valve connects to the inlet pipe, completing a fluid circuit between the inlet pipe and outlet pipe.[142]

158. Oktay '244 describes using a "first liquid 41 (such as [a] fluorocarbon)" and a "second liquid 43 having a relatively higher-boiling point temperature" wherein the second liquid is "superimposed on the free surface of the first liquid so that an interface 45 is formed."[143] This embodiment is intended to be used as a two-phase immersion cooling system because the lower liquid, i.e. the first liquid, with a lower boiling point, is designed to remove heat from the "electronic solid state computer components" as described in the invention by boiling on the surfaces of the components. As described in the Background section of this report, this type of heat removal is called "pool boiling" and involves the change in phase from the liquid to the vapor phases as a result of absorbing the heat dissipated by the components.

159. In another embodiment, depicted in Fig. 2, the apparatus may consist of an inner (73) and an outer container (85). The inner container contains a cooling coil (87) to remove the heat from the warm liquid. The inner container also has a plurality of overflow orifices (91) at the level of the condensing liquid. Warm liquid continuously overflows and dribbles down the walls of the inner rectangle container. The warm liquid pools within the outer container, and is maintained at a predetermined level by a pump (97) that draws the liquid from the outer container through the outlet pipe to a heat exchanger (99). The heat exchanger dissipates the heat of the warm liquid at a remote location or has cooling liquid flowing through it. The pump 97 discharges the cooled liquid to the inlet pipe (101) which distributes the cooled liquid in the inner container, thereby completing a fluid circuit from the inlet pipe to the outlet pipe.[144] With the overflow arrangement, the heat transfer rate of the entire system is increased and a more efficient system results.[145]

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[137] *Id.* at 2:31-33.
[138] *Id.* at 2:31-43.
[139] *Id.* at 2:64-68.
[140] *Id.* at 2:68-71.
[141] *Id.* at 2:64-72.
[142] *Id.* at 3:2-4.
[143] *Id.* at 2:44-50.
[144] *Id.* at 3:33-61.
[145] *Id.* at 3:74-2:1.

160. Oktay '244 identifies that the overflow "contributes to cooling the inner container and its contents" and that "with the overflow arrangement, the heat transfer rate of the entire system is increased and a more efficient system results."[146] Below is an illustration of Oktay '244's second described embodiment:

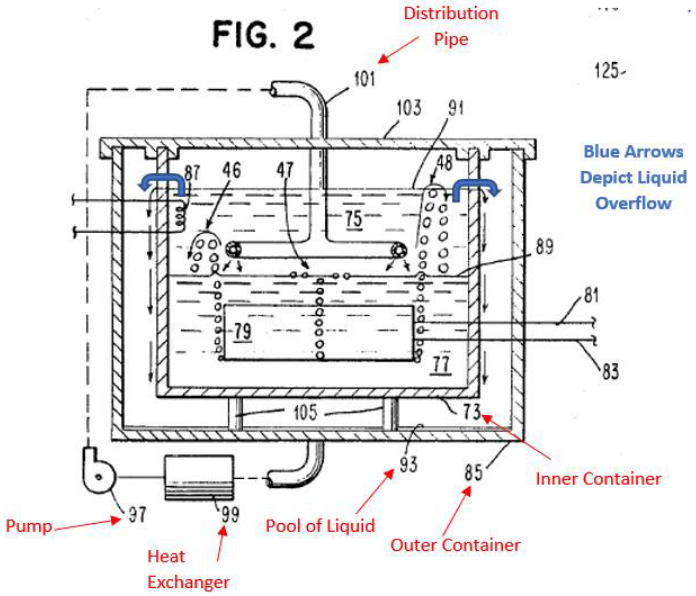

Figure 2 (annotated) is a partially-schematic, cross-sectional showing an embodiment of Oktay '244.

161. Oktay '244's second embodiment is intended to operate as a single-phase system. In this system, the electronic components are in direct contact with the immersion coolant, but the coolant does not experience pool boiling. Instead, the coolant removes heat from the components by single-phase convection, as described in the Background section of this report and is the same method utilized in the system described in the '457 patent.

162. Oktay '244 issued on October 15, 1968. I understand that Oktay '244 therefore qualifies as prior art to the '457 and '446 patents under at least 35 U.S.C. § 102(b) (pre-AIA) and 35 U.S.C. § 102(a)(1)(AIA).

JP '758

163. JP '758, titled Liquid Cooling Bias Testing Device, discloses a cooling apparatus that houses a liquid coolant of insulating oil and has a semiconductor and a sensor disposed in the circulation path of the liquid coolant.[147] The apparatus allows for immersing a plurality of objects (3) in the coolant.[148]

[146] *Id.* at 3:69-4:1.
[147] JP '758 at [0005], [0008].
[148] *Id.* at [0008].

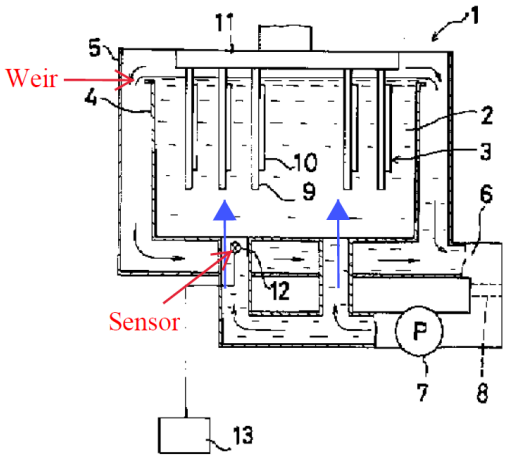

Figure 1 (annotated) is a longitudinal sectional view of an embodiment of JP '578.

164. The apparatus has an inner tank (4) and an outer tank (5).[149] The coolant forms a circulation path between the inner tank and the outer tank. A pump (7) is positioned in the outer tank in the circulation path near the bottom of the inner tank. The liquid coolant is pumped into the bottom of the inner tank (4). The liquid coolant then overflows from the inner tank (4) and is cooled by a cooling pipe. A filter (8) that is upstream of the pump (7) in the circulation path removes impurities mixed in the liquid coolant.[150]

165. A semiconductor device (10) is situated in the inner tank for temperature tests.[151] A sensor is also disposed in the circulation path to detect the insulating resistance of the coolant and thereby the concentration of the conductive impurities in the coolant.[152] The output signal of the sensor (12) is sent to a control circuit (13). When the concentration of impurities in the apparatus exceeds a threshold, the control circuit interrupts operation of the apparatus.[153]

166. JP '758 was published on October 20, 1992. I understand that JP '758 therefore qualifies as prior art to the '457 and '446 patents under at least 35 U.S.C. § 102(b) (pre-AIA) and 35 U.S.C. § 102(a)(1) (AIA). JP '758 was not before the examiner during prosecution.

Pfahnl Application

167. Pfahnl Application, titled Air Cooling Architecture for Orthogonal Board Architectures, discloses a system, depicted below, that uses air for cooling orthogonally oriented arrays of parallel circuit boards and is particularly well suited for data centers.[154] The system includes two distinct

[149] *Id.* at [0008].
[150] *Id.* at [0008].
[151] *Id.* at [0008].
[152] *Id.* at [0009]-[0011].
[153] *Id.* at [0009]-[0011].
[154] Pfahnl Application at Abstract, [0039].

air cooling paths: a first cooling path for cooling the circuit boards and a second cooling path for cooling the circuit boards.[155]

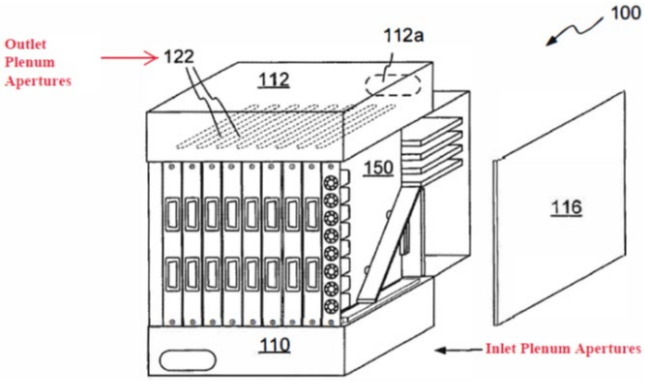

Fig. 2

Figure 2 (annotated).

168. The second cooling path includes an inlet plenum and an outlet plenum. An air inlet is formed at the front of the inlet plenum, and air outlet is formed at the rear of the outlet plenum.[156] The inlet plenum and the outlet plenum both include apertures. The apertures direct air across and between different circuit boards.[157] The inlet plenum or the outlet plenum may include fans.[158] During operation, air is drawn into the inlet plenum through the air inlet, passed through the apertures of the inlet plenum, across the circuit boards, through the apertures of the outlet plenum 112, and out of the air outlet.[159] The air thus follows an S-shaped course, entering the system through the lower front, passing upwardly between the circuit boards, and exiting the system from the upper rear.[160]

169. Pfahnl Application was published on December June 15, 2006. I understand Pfahnl Application therefore qualifies as prior art to the '457 and '446 patents under at least 35 U.S.C. § 102(b) (pre-AIA) and 35 U.S.C. § 102(a)(1) (AIA).

[155] *Id.* at [0026].
[156] *Id.* at [0027].
[157] *Id.* at [0028].
[158] *Id.* at [0029].
[159] *Id.* at [0030].
[160] *Id.* at [0037].

Krajewski '511

170. Krajewski '511, titled High Density Interconnect Apparatus"), describes cooling a plurality of central processing ("CP") boards that are stacked with a plurality of common memory module ("CMM") boards in a close configuration and immersing it in a cooling fluid.[161]

171. "In the preferred embodiment, the CP board stack 11 contains eight CP boards 12 and each CMM board stack 13 contains four memory boards 14,"[162] as illustrated below:

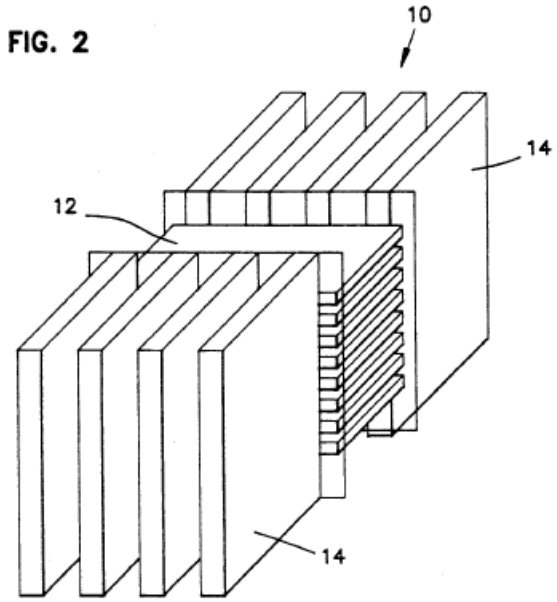

Figure 2.

172. Krajewski '511 discloses that the package of electrical appliances, CP boards and CMM boards, are immersed in dielectric fluid for cooling, stating "[t]he resulting preferred package of stacked CP boards surrounded on two sides by CMM boards stacked in perpendicular planes is submerged in a thermally conductive, electrically insulated bath to provide sufficient cooling of the boards during operation."[163]

173. Krajewski '511 discloses that the fluid comes up through the area below the boards into a manifold which directs it through the CP board stack 11 from the rear to the front and also in an upward direction through the CMM board stacks.[164] The fluid then flows out the top of the inner wall of the board stack container and is returned down between the inner and outer walls of the

[161] Krajewski '511 at [57], 1:5-14, 4:59-62.
[162] *Id.* at 4:51-54.
[163] *Id.* at 2:41-45.
[164] *Id.* at 4:63-66.

board stack container 4 and to the base. The fluid is returned to a reservoir and associated chiller.[165] An illustration of Krajewski '511's fluid flow through the board stacks is illustrated below:

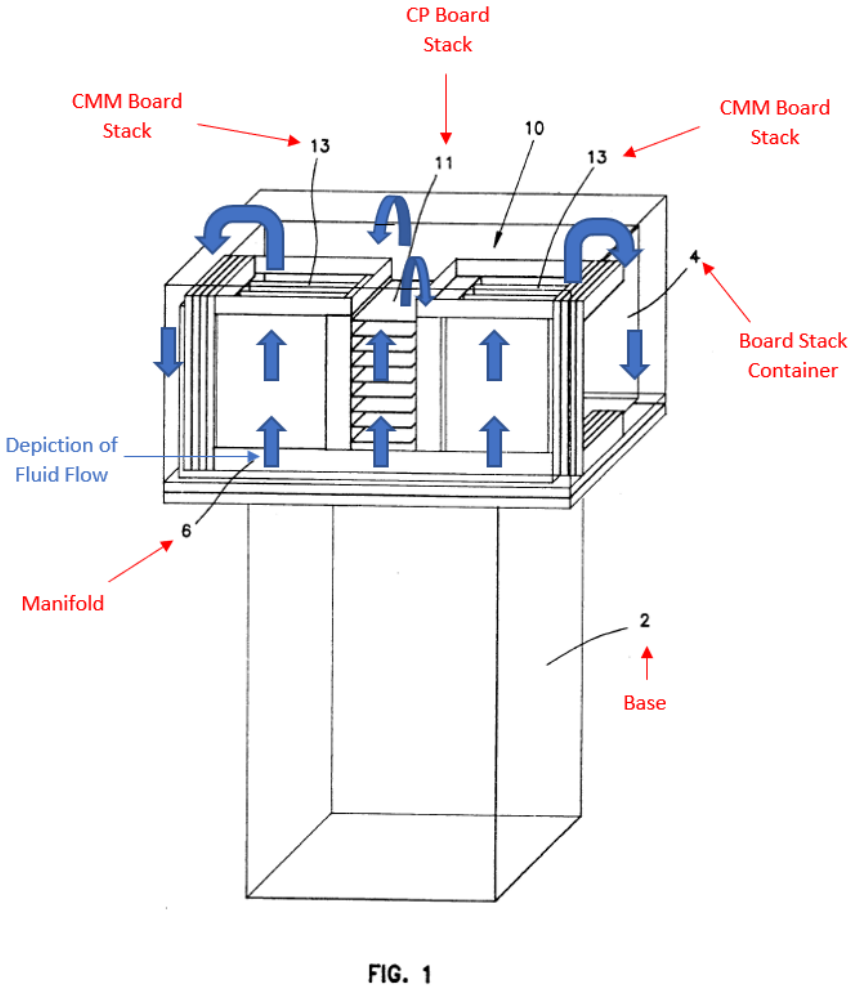

Figure 1 (annotated).

174. Krajewski '511 published on December 1, 1992. I understand that Krajewski '511 therefore qualifies as prior art to the '457 patent under at least 35 U.S.C. § 102(b) (pre-AIA) and 35 U.S.C.§ 102(a)(1) (AIA).

Cray '538

175. Krajewski '511 incorporates by reference U.S. Pat. No. 4,590,538 to Cray, Jr. ("Cray '538"), issued May 20, 1986.[166] Cray '538, titled Immersion Cooled High Density Electronic Assembly, discloses an immersion cooling system for high density electronic assemblies.[167]

[165] *Id.* at 4:66-5:5.
[166] *Id.* at 4:59-5:10.
[167] Cray '538 at [57].

Cray '538 is directed towards "a liquid immersion and circulation system to successfully handle the very high heat load produced."[168]

176. The system consists of coolant supply columns and coolant removal columns. The coolant supply columns include distribution manifolds, which distribute incoming coolant. The coolant flows over the electronic assemblies, causing the coolant to heat. The heated coolant rises in coolant removal columns and flows over outlet standpipes. The coolant flows through holes in the outlet standpipes and over the tops of the standpipes.[169] Pumps withdraw the coolant to a reservoir. The pumps also circulates the coolant through an external heat exchanger, where the coolant is cooled by tap water or other cooling medium before it is recirculated in the system.[170]

177. Cray '538 describes its preferred embodiment stating, "FIG. 12, which is a top view of the tank in FIG. 1 with the cover removed, it will be seen that there are 16 stacks of circuit modules, three of which have been given reference number 30a, 30b and 30c. These stacks consist of a number of modules comprising a power supply or a plurality of horizontal circuit boards."[171] Cray '538 continues stating "[e]ach stack of modules is supported by a pair of vertical support frames 31, 32 which are adjacent the stack on either side" and that "[t]he module support frames 31 and 32 are vertically oriented planar shaped structure perforated with a large number of holes to permit the coolant to flow through them."[172] This module and support frame arrangement is illustrated below:

[168] *Id.* at 2:36-38.
[169] *Id.* at 6:47–55.
[170] *Id.* at [57], cl. 12, 6:15–17.
[171] *Id.* at 4:64-5:2.
[172] *Id.* at 5:10- 14.

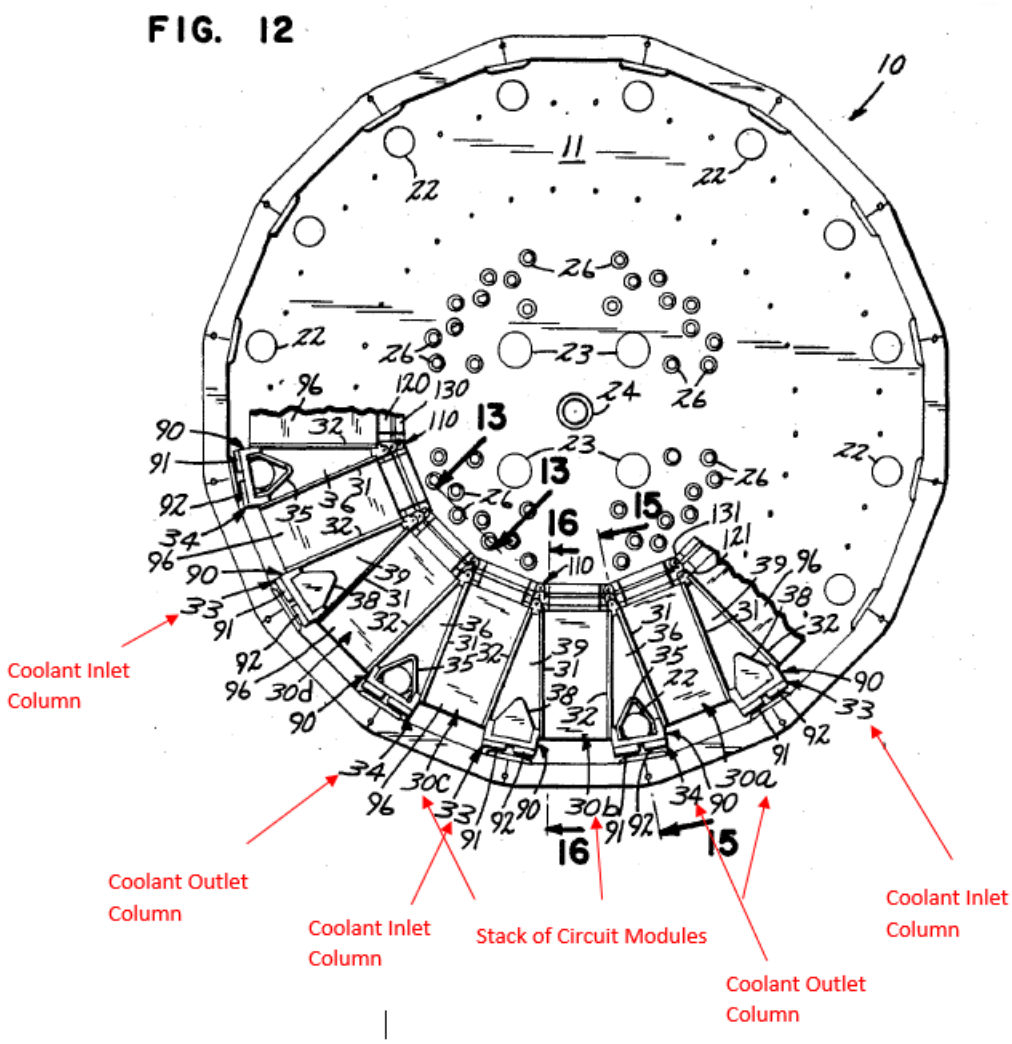

Figure 12 (annotated).

178. Cray describes that the "adjacent module stacks are formed sector or triangular shaped areas, indicated by reference numbers 33 and 34, which form vertical coolant flow columns."[173] Cray further identifies that "inlet columns are indicated by reference 33, and these alternate around the computer with outlet columns 34" and that the "outlet columns 34 have standpipes positioned therein" which are "triangular shaped, but are smaller than columns 34 to provide spaces 36 between standpipe 35 and the adjacent module supports 31, 32 to allow coolant [] rising to the top to flow over the top of the standpipe and flow down the center thereof."[174] An illustration of the inlet and outlet columns, and the coolant flow path is depicted below:

[173] *Id.* at 5:20-23.
[174] *Id.* at 5:23-31.

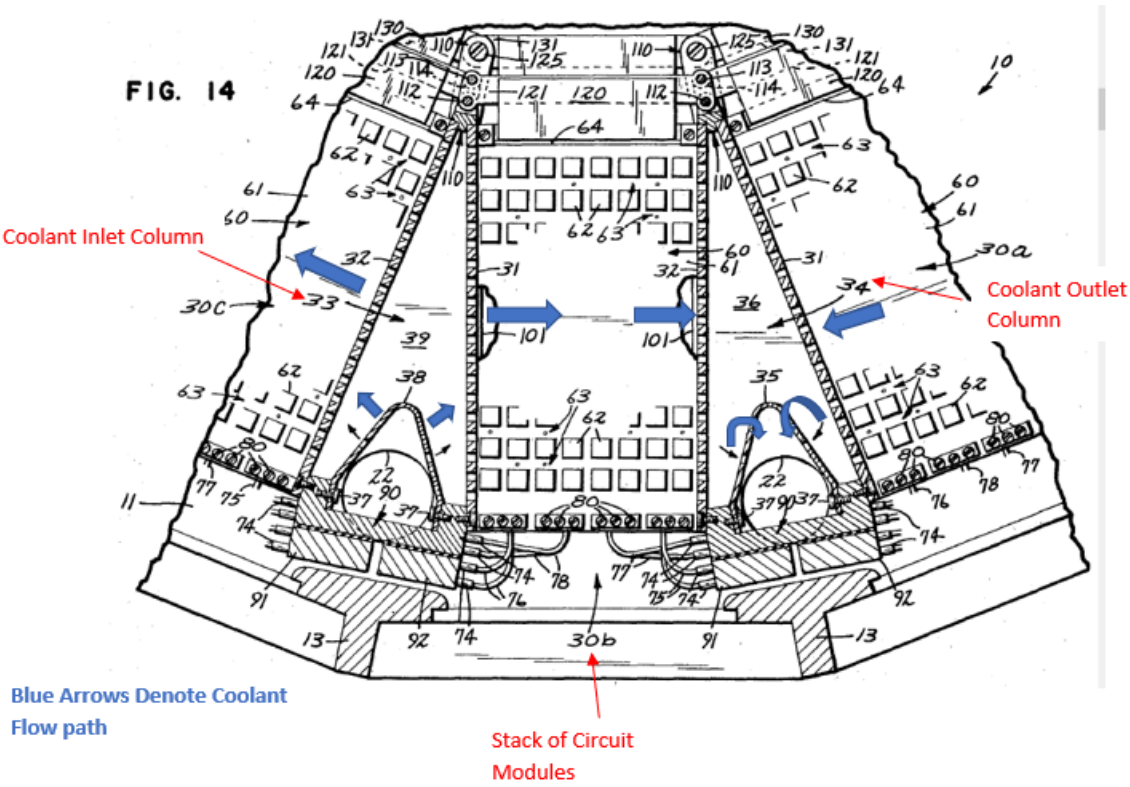

Figure 14 (annotated).

179. Cray further describes the flow path in that "coolant enters the tank in the vertical coolant flow columns 33, then travels horizontally through multiple paths . . . across and between all modules and all horizontal circuit boards that make up the modules . . . pick[ing] up the heat generated by their circuit boards"[175] Then, the coolant "flows vertically upward in zones 36 in columns 34 outside the standpipes, then flows over the tops of the stand-pipes 35 down through them for recirculation through the heat exchanger."[176] Cray identifies that "the effect of inlet columns 33 is to provide fresh, equally cool coolant to all modules, both high and low in the stack."[177]

180. Cray describes that a "pair of circulation pumps 40, 41 and corresponding heat exchangers 42, 43 are provided for circulating the liquid coolant through the computer immersed within the tank."[178] In order to cool the heated coolant, Cray identifies that "[p]ump 40 circulates coolant through heat exchanger 42, where it is cooled by tap water or other cooling medium circulated through the heat exchanger."[179] Following this cooling process, "[t]he cooled coolant flows through line 44, which branches to supply coolant to the left and right supply columns 33 of

[175] *Id.* at 6:30-36.
[176] *Id.* at 6:38-41.
[177] *Id.* at 6:41-43.
[178] *Id.* at 6:12-15.
[179] *Id.* at 6:15-18.

FIG. 2."[180] Figure 2 depicts an additional illustration of the system's coolant flow path, omitting the logic and memory module stacks normally positioned between the module support frames:

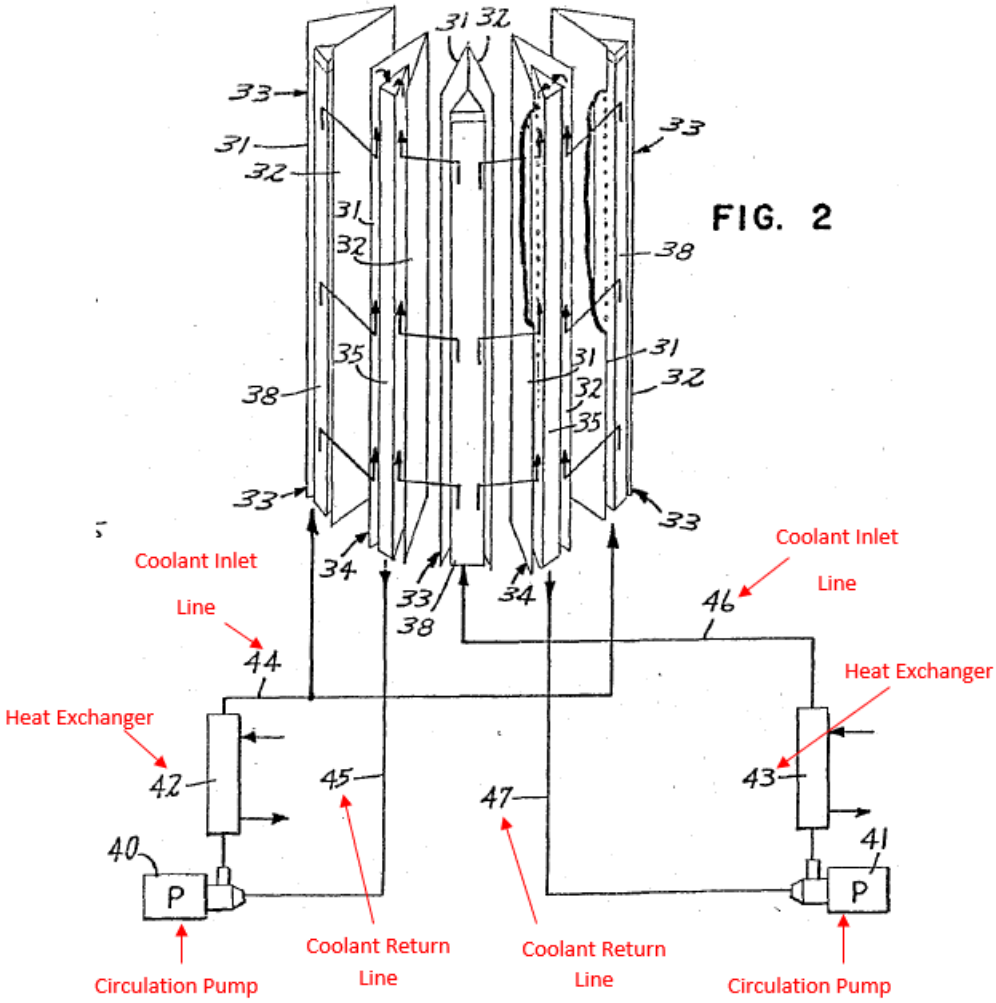

Figure 2 (annotated).

181. In certain instances, such as maintenance of a server, "the coolant pump up/pump down system, rather than the coolant circulation system" activates and "supply/drain hole 23 connects by a line 55, which branches to an inlet of the pump down pump 56" which returns the coolant to "reservoir 50".[181]

[180] *Id.* at 6:18-20.
[181] *Id.* at 6:58-7:11.

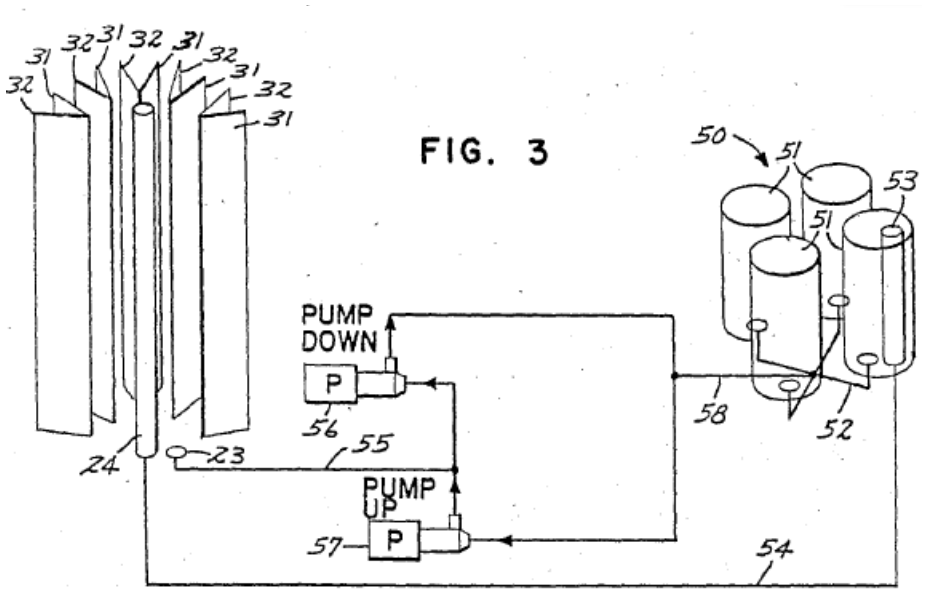

Figure 3.

Gryzhin '013

182. Gryzhin '013 is titled "Liquid-Cooling System for Electronic Devices," and, similar to the '457 patent, is directed towards a "system for cooling equipment by immersion in a liquid means placing electronic components heated in the process of operation in individual sealed containers."[182]

183. Gryzhin '013 identifies certain known difficulties within the field that its system seeks to address, namely that "[t]he higher the temperature of a working electronic component, the higher the likelihood of its failure."[183]

184. Gryzhin '013 describes four embodiments of its cooling system. In each embodiment, "heat-generating components of which are cooled by immersion method, enclosed in a sealed container equipped with a disconnect inlet fitting, disconnected at the initial stage of removing the unit from the support, and a hole or pipes for draining the coolant."[184] Gryzhin '013 describes that "compartment 14 is intended for horizontal placement of power supplies for the entire chassis and is located at the bottom of it and the manifold 16. Containers with equipment 12, 13 and blocks located in the compartment 14 are filled with dielectric coolant, which is in direct contact with all components located inside them. The liquid cools them while contacting the heat-generating elements."[185]

[182] Gryzhin '013 at [54], 5:21-22.
[183] *Id.* at 5:5-6.
[184] *Id.* at 6:30-33.
[185] *Id.* at 8:28- 31.

185. The illustration below depicts "a chassis with cooled containers of different types, the body 11 with container 12 and containers of type 13 for electronics."[186]

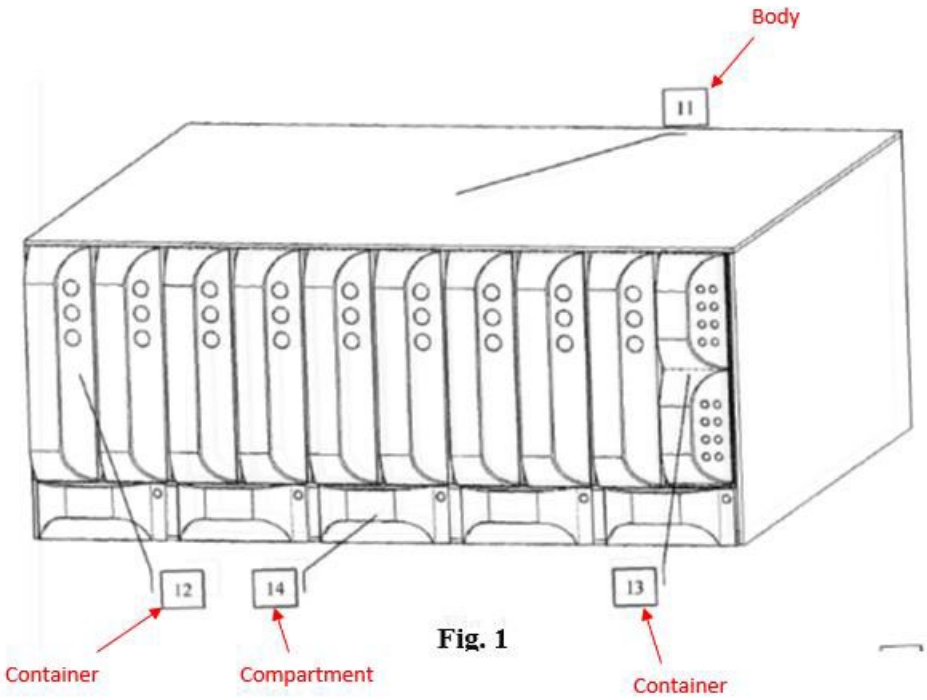

Figure 1 (annotated).

186. Gryzhin '013 describes that each container is equipped with "common pipe 17 for feeding cooled liquid with quick disconnect valves 34" and "cooling system inlet fitting with disconnect valve 29."[187] Additionally, when the container is in operation, as opposed to maintenance, "plug 40, rigidly fixed to the base 39, closes the drain hole 36" which allows coolant to "enter[] the container from the fitting 29 and, depending on the implementation of the selected method of liquid cooling, spreads inside the working are."[188]

187. Gryzhin '013 describes that the "working area" of the container is sealed from below, and it "gradually fills up to the upper edge of partition 37 and begins to overflow into the drain channel 35 of the container, and from there into the common "hot" liquid collector 16."[189]

188. Figure 5 below depicts the "universal support without containers," and Figure 4 below depicts an "image of the supply unit and the proposed coolant drainage unit.

[186] *Id.* at 8:17-18.
[187] *Id.* at 9:5-6.
[188] *Id.* at 9:11-14.
[189] *Id.* at 9:14-16.

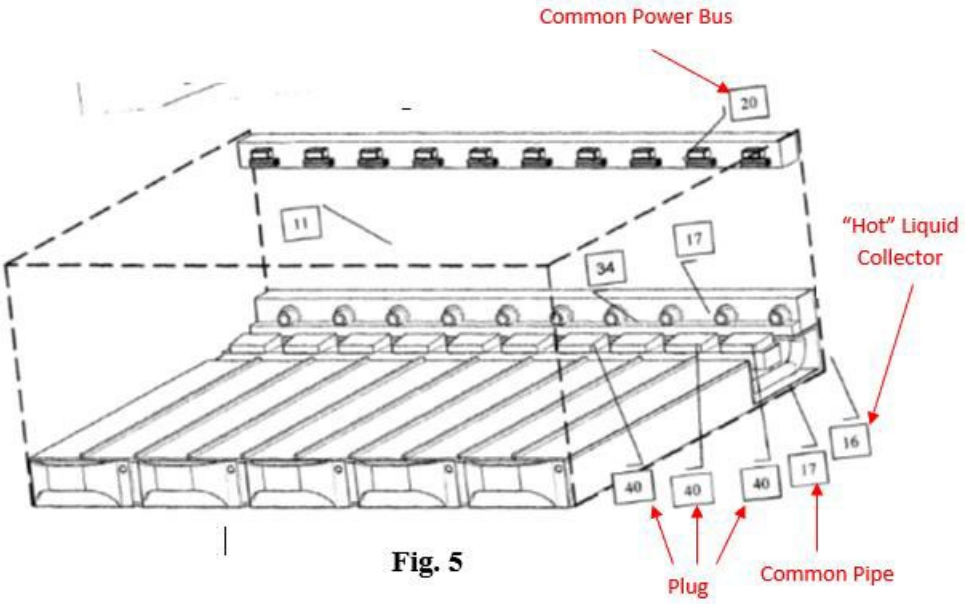

Figure 5 (annotated).

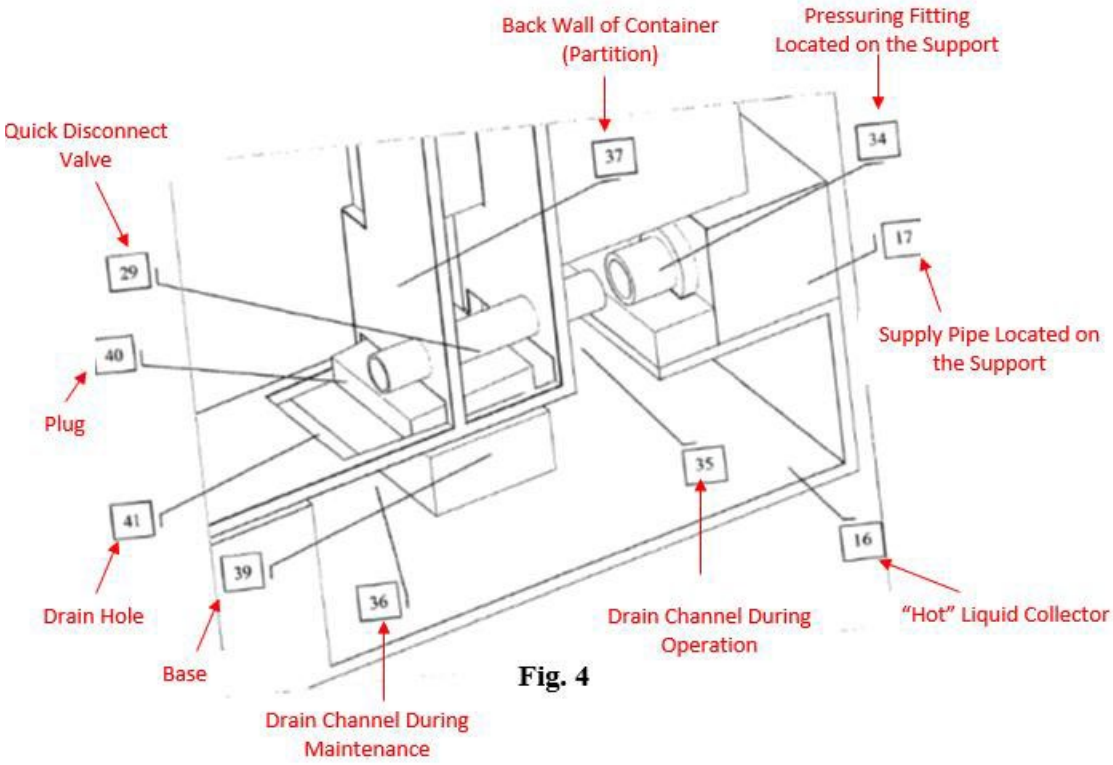

Figure 4 (annotated).

189. Gryzhin '013 depicts four embodiments of the claimed invention. In the first, "the liquid coolant is fed through the pipe to strongly heated elements with further forced draining of the

liquid into the drainage system and at the same time the container is filled with coolant, thus cooling the rest of the elements (Fig. 6, 7)."[190]

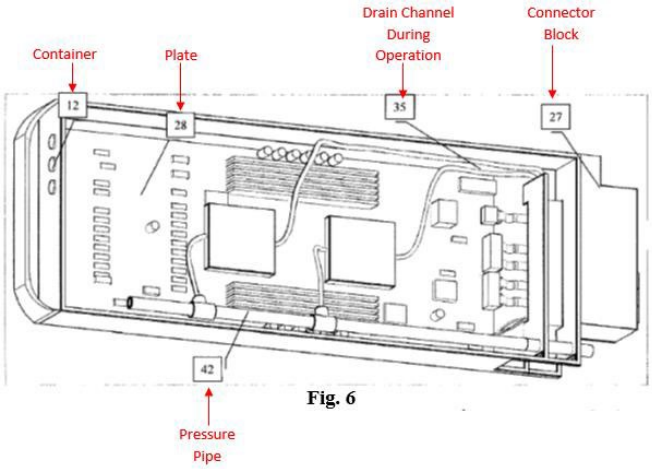

Figure 6 (annotated).

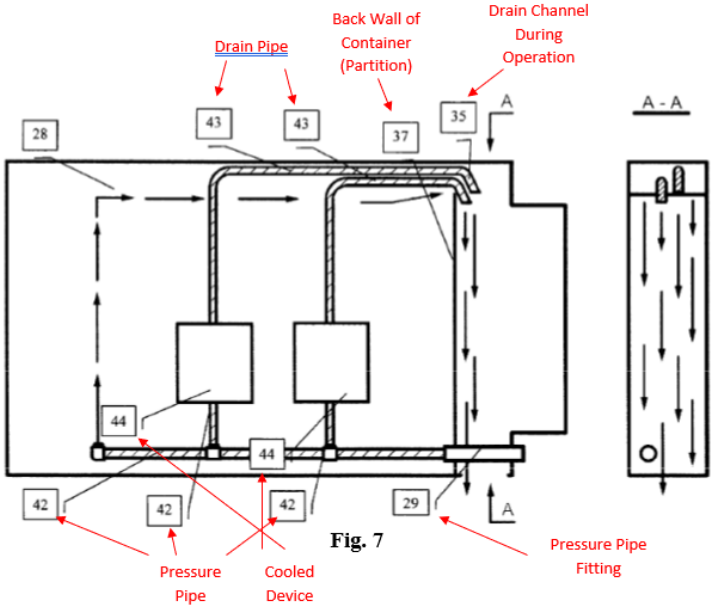

Figure 7 (annotated).

190. In the second embodiment, "the liquid coolant is fed through the pipe to strongly heated elements with the further discharge of liquid into the container space and at the same time filling the container with coolant and, thus, cooling the remaining elements (Fig. 8)."[191]

[190] *Id.* at 5:33-35.
[191] *Id.* at 6:1-4.

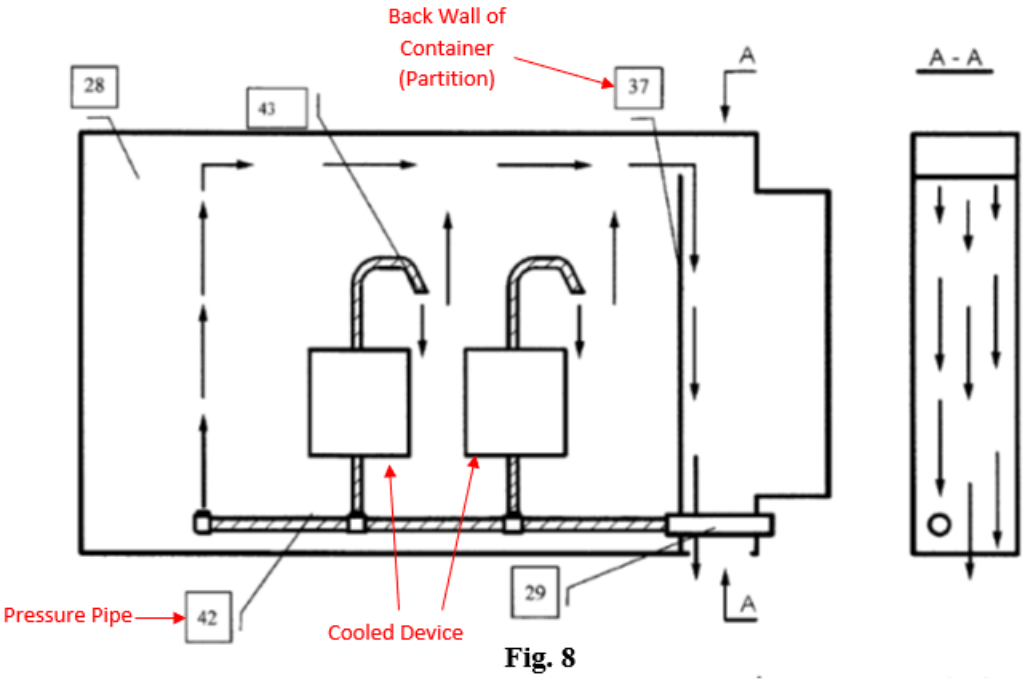

Figure 8 (annotated).

191. In the third embodiment, "the liquid coolant is supplied through a pipe to strongly heat[ed] elements with the further forced discharge of liquid into the drainage system (Fig. 9)."[192]

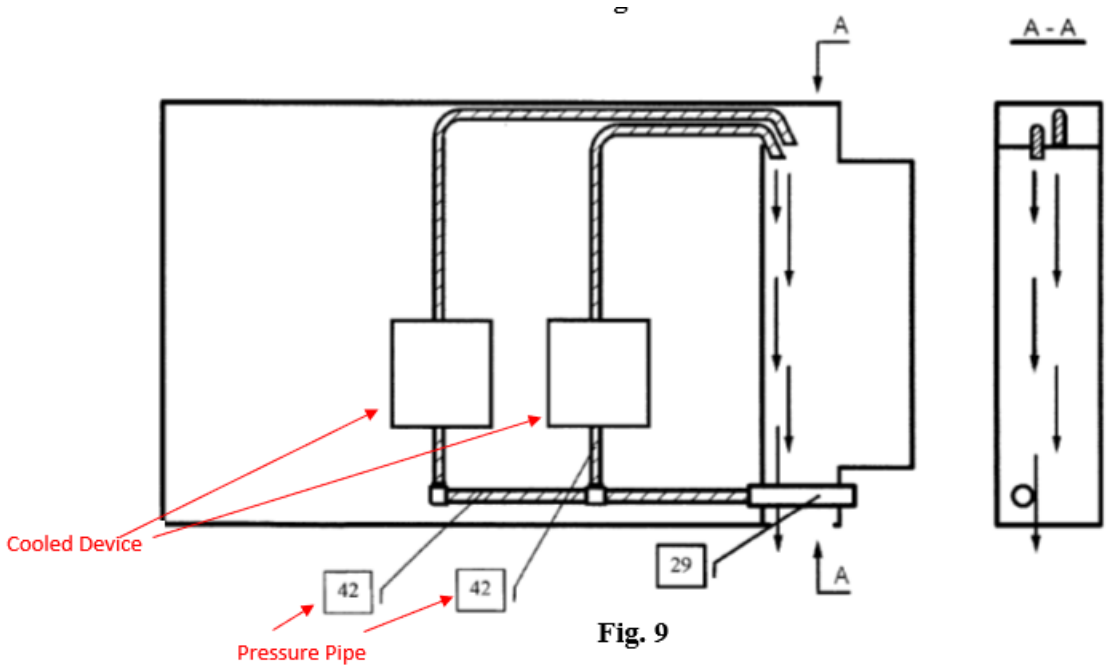

Figure 9 (annotated).

[192] *Id.* at 6:5-6.

192. In the fourth embodiment, "the container is filled with liquid coolant, which cools all the elements (Fig. 10)."[193]

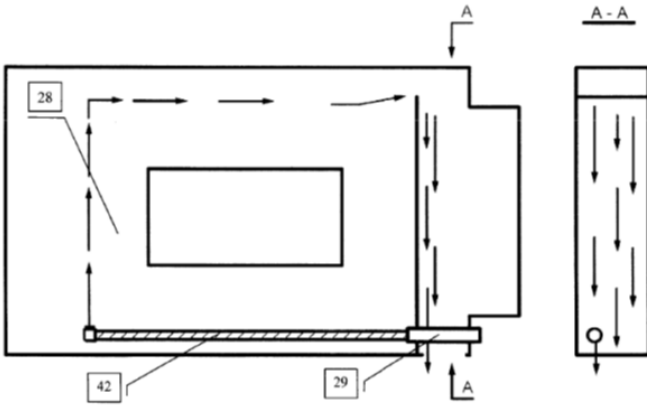

Fig. 10

Figure 10.

193. In at least the embodiments depicted by Figures 7, 8, and 10 above, the container "becomes almost completely filled with liquid" as the "liquid level is determined by the flat clearance of drain device 35".[194] Gryzhin '013 describes further that "[w]hen the liquid reaches the level of the upper edge of the drain device 35, the subsequent liquid entering from the bottom displaces the upper layers, which flow into the manifold 16."[195]

194. Gryzhin '013 describes that a "heat exchanger 56" can be used for cooling the heated liquid, and that "heat exchanger 56 can be made, for example, on the basis of a radiator with electric fans."[196]

195. Gryzhin '013 was filed on March 19, 2012. I understand that Gryzhin '013 qualifies as prior art to the '457 and '446 patents under at least 35 U.S.C. § 102(b) (pre-AIA) and 35 U.S.C. § 102(a)(1) (AIA).

Quon '108

196. Quon '108, titled Cooling of Semiconductor Power Modules by Flushing with Dielectric Liquid, discloses a system for cooling an electronic power module that consists of semiconductor dies mounted on a printed wiring board by flushing the electronic power module with dielectric liquid coolant.[197]

[193] *Id.* at 6:7.
[194] *Id.* at 10: 31-32.
[195] *Id.* at 10: 33-35.
[196] *Id.* at 11:3-5.
[197] Quon '108 at Abstract, 1:6-12, cl. 1.

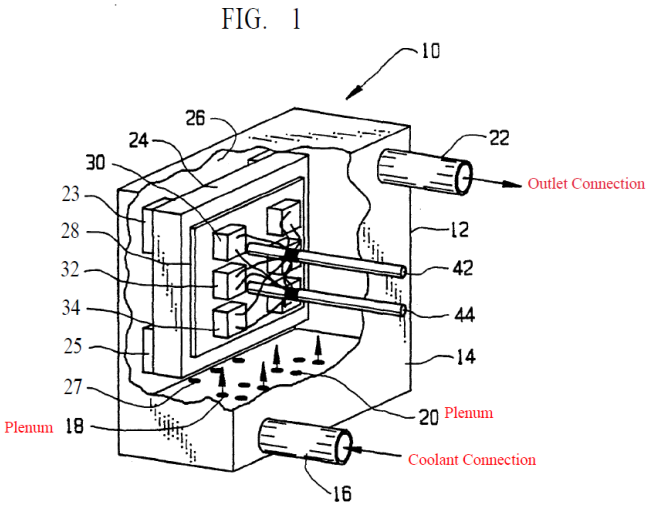

Figure 1 (annotated).

197. The electronic power module is contained in a housing.[198] The semiconductor dies and printed wiring board are in a vertical orientation within the housing.[199] The bottom of the housing is formed by a plenum that has a group of nozzle holes.[200] The nozzles direct the dielectric liquid coolant upward over the semiconductor dies and printed wiring board.[201] The nozzle hole groups are directed to increase the velocity of the flowing dielectric liquid across the dies for improved heat transfer directly between the dies and the fluid.[202] An outlet connection near the top of the housing permits the dielectric liquid to pass from the housing.[203]

198. Quon '108 issued on September 5, 1995. I understand that Quon '108 therefore qualifies as prior art to the '457 and '446 patents under at least 35 U.S.C. § 102(b) (pre-AIA) and 35 U.S.C. § 102(a)(1) (AIA).

Rolfson '298

199. Rolfson '298, titled Method and Apparatus for Uniformly Baking Substrates Such as Photomasks, discloses a method and apparatus for maintaining a liquid bath at a constant and uniform temperature for semiconductor fabrication.[204] The system may be utilized for cooling or quenching of a substrate or other similar work piece.[205]

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[198] *Id.* at 2:10-13.
[199] *Id.* at 1:60-64.
[200] *Id.* at cl. 1, 2:10-23.
[201] *Id.* at 1:60-64, 2:31-38.
[202] *Id.* at 2:49-52.
[203] *Id.* at 2:21-24.
[204] Rolfson '298 at [57], 1:9-10.
[205] *Id.* at 7:53-63.

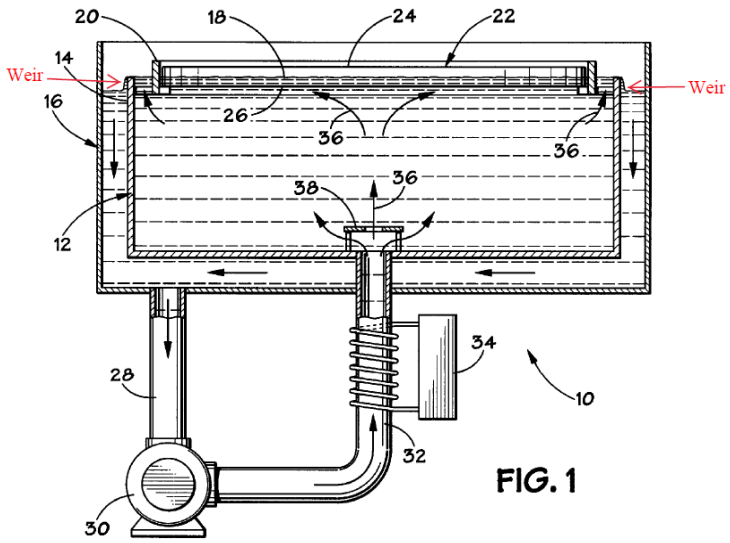

Figure 1 (annotated).

200. The apparatus includes a first tank for containing the liquid bath. The first tank may be disposed inside a second tank to help facilitate re-circulation of the liquid bath.[206] The second tank is, in actuality, a continuous overflow located around the periphery of the first tank.[207] In an alternate embodiment, the system does not consist of a second tank. Instead, the first tank has a drain or overflow that is connected to a pump system.[208] The second tank has a return line that accommodates any excessive liquid bath that flows over the wall of the first tank. The return line is coupled to a circulating device such as a pump. A supply line is coupled to the pump and carries the liquid bath back to the first tank 12. A temperature control unit, such as a heat exchanger, is disposed adjacent the supply line. The temperature control unit may have a broad temperature range, such as 80° to 200° C., with a preferred operating range of 100° to 120° C., and precise temperature control such as ±0.05 to 0.1.[209]

201. A baffle or series of baffles are used to control the flow of the liquid bath and to properly disperse it as it enters the first tank.[210] The flow of the liquid bath, as generally shown by fluid flow lines, is upward and radially outward from the center of the first tank. The wall of the first tank serves as a weir, or a simple fluid level control, allowing excess fluid to spill over in the second tank, and thereby completing the fluid circuit.[211] The apparatus offers a more uniform and efficient heat transfer process.[212]

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[206] *Id.* at 3:61-4:3.
[207] *Id.* at 7:49-52.
[208] *Id.* at 7:39-43.
[209] *Id.* at 4:64-5:10.
[210] *Id.* at 5:13-30; 7:21-24.
[211] *Id.* at 5:13-30
[212] *Id.* at 5:42-46.

202. Rolfson '298 issued on April 29, 2003. I understand that Rolfson '298 therefore qualifies as prior art to the '457 and '446 Patents under at least 35 U.S.C. § 102(b) (pre-AIA) and 35 U.S.C. § 102(a)(1) (AIA).

Attlesey '419

203. Attlesey '419, titled Liquid Submersion Cooling System, discloses a portable, self-contained system for cooling electronic devices by submersion in a dielectric liquid.[213] The heat-generating components of the electronic device are submerged in the dielectric cooling liquid in a tank. A pump transports warm dielectric cooling liquid from the top of the tank to outside of the tank into a heat exchangers. The pump can be submerged in the cooling liquid within the interior space or can be disposed outside the interior space.[214] The electronic device may rely on convection of the dielectric cooling liquid, thereby eliminating the need for a pump.[215]

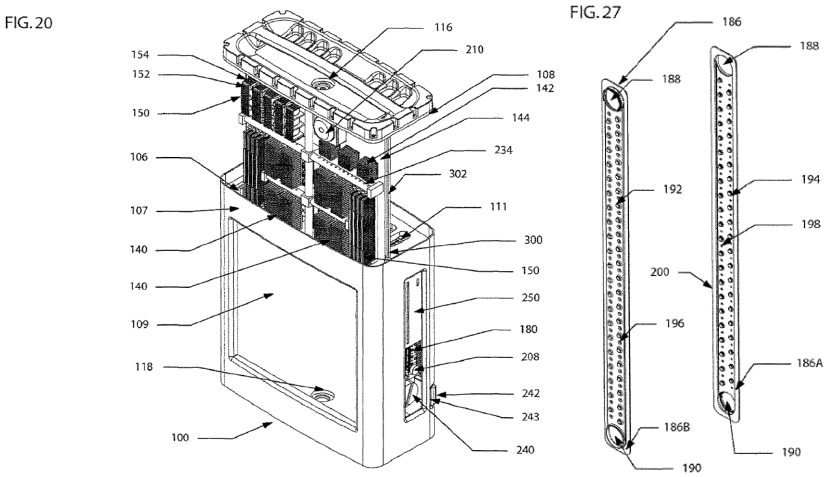


Figure 20 illustrates a perspective view of an embodiment of Attlesey '419 and **Figure 27** illustrates a pair of plates from Attlesey '419.

204. The heat exchanger includes a cooling liquid inlet, a cooling liquid outlet, and a flow path for the cooling liquid from the cooling liquid inlet to the cooling liquid outlet.[216] The heat exchanger may be comprised of a plurality of identical plates with holes defined by bosses that are connected together to form plenums that receive the dielectric liquid.[217]An air-moving device, such as a fan, can also be used to move air past the heat exchanger.[218]

205. In use, the liquid to be cooled flows into the inlet and the plenum at the top of the heat exchanger. The liquid flows downward past the bosses of the holes and transfers heat to the bosses. At the same time, air flows into the bosses of the holes for additional heat exchange. The cooled

[213] Attlesey '419 at [57], 4:13-24.
[214] *Id*. at 4:50-53, 5:52-6:9.
[215] *Id*. at 2:6-37.
[216] *Id*. at 2:6-37.
[217] *Id.* at 11:1-17.
[218] *Id*. at 2:6-37.

liquid collects in the plenum, and is pumped through the outlet of the heat exchanger and back into the tank.[219]

206. Nozzles may be incorporated to direct the flow of the liquid at specific, high-temperature areas.[220] In areas where there is significant heat, a spray bar assembly may be connected to the inlet of the tank. The spray bar assembly has a central passageway extending vertically and a plurality of branches or vents that horizontally within the tank. The branches include holes to direct cooled liquid upwardly onto the heat-generating components.[221]

207. Attlesey '419 was issued on August 30, 2011. I understand Attlesey '419 therefore qualifies as prior art to the '457 and '446 patents under at least 35 U.S.C. § 102(b) (pre-AIA) and 35 U.S.C. § 102(a)(1) (AIA).

208. Attlesey '419 has the same disclosure as U.S. Patent No. 7,403,392 and U.S. Patent Application Publication No. US 2008/0017355 to Attlesey, which issued or published on July 22, 2008 and January 24, 2008, respectively. I therefore understand that these references also qualify as prior art to the '457 and '446 patents under at least 35 U.S.C. § 102(b) (pre-AIA) and 35 U.S.C. § 102(a)(1) (AIA).

PRIORITY DATE OF THE ASSERTED PATENTS

209. I have examined whether the provisional applications, U.S. Provisional Patent Application No. 61/737,200, filed on December 14, 2012 and U.S. Provisional Patent Application No. 61/832,211, filed on June 7, 2013,[222] to which the Asserted Patents claim priority, describe the claimed invention and the manner of making and using it such that a POSA would be able to make the claimed invention without undue experimentation.

210. Based on my review, it is my opinion that neither the 2012 nor the 2013 Provisional discloses or teaches a POSA how to make the following limitations of the Asserted Patents:

(a) "a weir, integrated horizontally into the long wall of the tank adjacent all appliance slots, having an overflow lip adapted to facilitate substantially uniform recovery of the dielectric fluid flowing through each appliance slot;" and

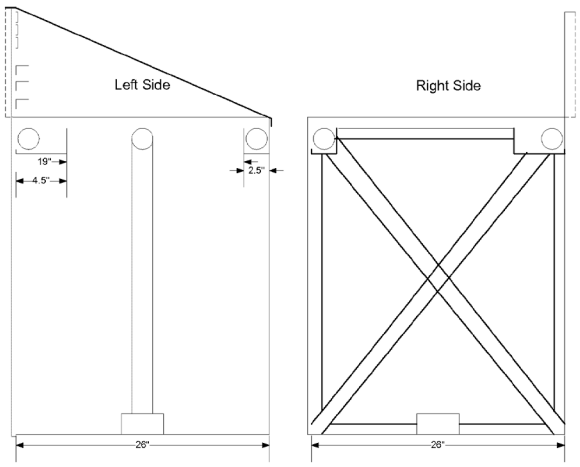
(b) "a plenum . . . adapted to dispense the dielectric fluid substantially uniformly upwardly through each appliance slot."

The 2012 Provisional

211. The 2012 Provisional lists as inventors, John H. Miller Jr.; James P. Koen; John C. Tribou; Mike Rainone; Talbot Presley; Jeffrey Van Myers; Christopher L. Boyd; Kenneth D. Tooke; and

[219] *Id.* at 11:42-53.
[220] *Id*. at 5:4-10.
[221] *Id.* at 12: 1-14.
[222] 2012 Provisional at MIDAS0004047; 2013 Provisional at MIDAS0003334.

D. Christopher T. Laguna.[223] It describes a cooling system that houses spray bars that each have a number of spray heads.[224]



212. The spray bars and spray heads serve as structures for dispensing liquid. The 2012 Provisional identifies as a goal "substantially constant pressure at all Spray Heads (a bottom of Tank)."[225]

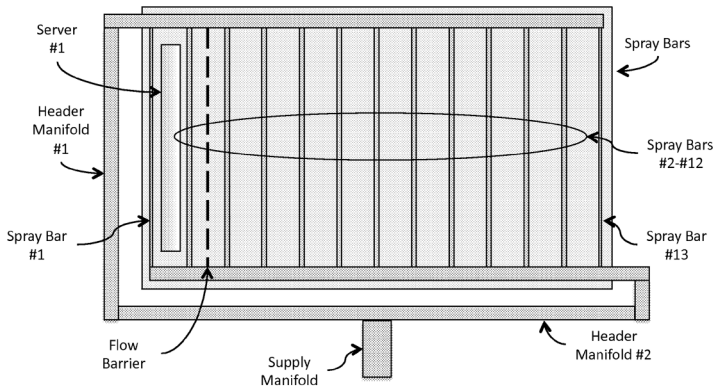
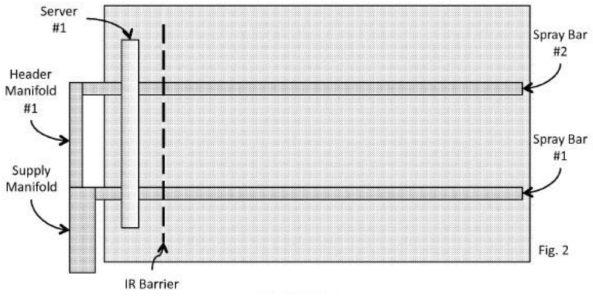


Fig. 1

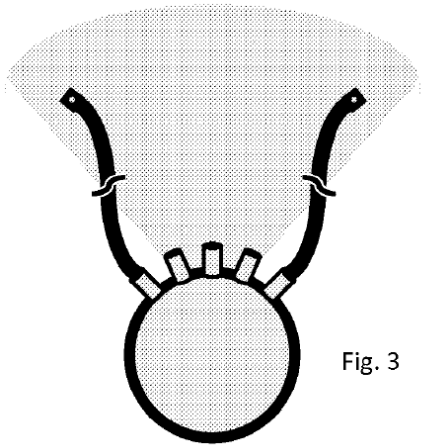
213. The 2012 Provisional explains that "the spray bars are spaced such that [a] server may be suspended in each inter-spray bar gap, thus forming respective 'flow slots,' the flow patterns of which project upward from the spray heads, through the inter-server gaps, and ultimately into open fluid return channel(s) (e.g., weirs) extending horizontally along the long side(s) of the tank."[226] In addition to, or as a supplement to, the weir, the system may consist of active fluid extraction by suction.[227]

[223] 2012 Provisional at MIDAS0004047.
[224] *Id.* at MIDAS0004058.
[225] *Id.* at MIDAS0004055.
[226] *Id.* at MIDAS0004055.
[227] *Id.* at MIDAS0004058.

214. The 2012 Provisional discloses two arrangements of spray bars and spray heads. Fig. 1 (above) depicts an inlet tube (labeled a "Supply Manifold") that feeds liquid into top and bottom header manifolds labeled as "Header Manifold #1" and "Header Manifold #2."[228] The top and bottom header manifolds supply liquid to a parallel arrangement of spray bars which extend transverse to the long wall of the tank, parallel to the appliance slots. Liquid appears to be supplied from both ends of each spray bar from the header manifolds.[229]



215. Figure 2 (above) depicts a different arrangement. In Figure 2, only two spray bars are present, each of which is supplied by a manifold on a single end of the spray bar. Contrary to the spray bars in Figure 1, the spray bars in Figure 2 run transverse to the shorter walls of the tank, perpendicular to each appliance slot.[230]



216. Figure 3 (above) depicts a longitudinal spray bar with spray heads distributed radially.[231] The 2012 Provisional further provides the following disclosure:[232]

[228] *Id.* at MIDAS0004055-4056.
[229] *Id.* at MIDAS0004055-4056.
[230] *Id.* at Fig. 1.
[231] *Id.* at MIDAS0004057.
[232] *Id.* at MIDAS0004057.

[0019] (Option) Also as in Fig. 2, orient the Spray Bar(s) longitudinally with Spray Head(s) aligned with inter-blade gaps. If more than one Spray Head per gap, arrange radially so as that the flow pattern resembles a fan, as in Fig. 3. Individual Spray Heads can be fan-shaped. Spray Heads can be fixed flow rate or variable flow rate or a mixture of both as required for specific applications. Variable flow rate can be adjusted manually or by servo-mechanism.

[0020] (Option) Also as shown in Fig. 3, Supplementary Spray Bars, oriented vertically but with horizontally-oriented 'aimable' Spray Head(s), can be provided to provide flow of cooling fluid directly onto local blade hotspots. Such Supplementary Spray Bars can be supplied either from the primary Spray Bars or via special Supplementary Manifolds disposed either at the bottom/top of the tank or adjacent the tank side(s).

[0022] (Option) Spray Head design can be selected to match heat signature of each blade. Spray Heads can be fixed flow rate or variable flow rate or a mixture of both as required for specific applications. Spray Heads can be mounted on short flex-tubes to provide directional distribution for augmented cooling. In some applications, selected Spray Bars/Heads can be supplied from an auxiliary cooling source operating independently of the main fluid source.

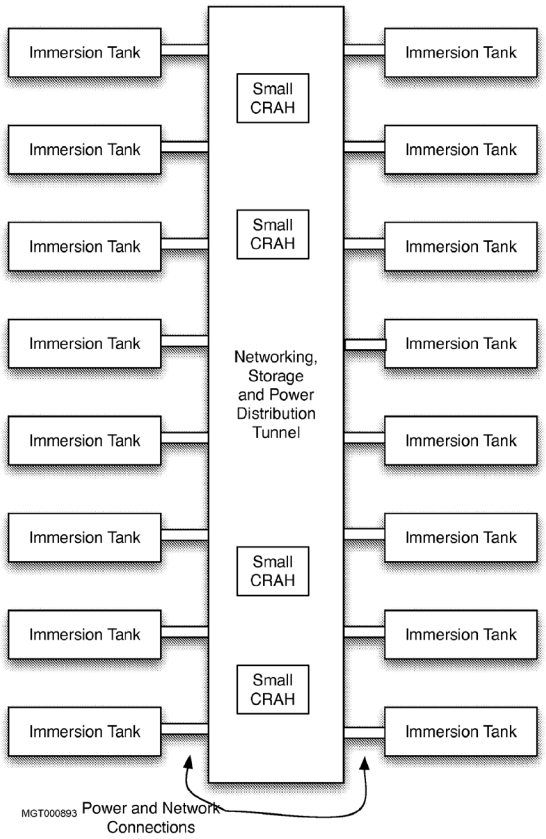
217. Each spray bar also has shutoff valves at each end. The shutoff valves may be partially closed to compensate for any reduced heat being conducted into flow slots.[233] Each pair of shutoff valve may be controlled by a single valve controller in response to temperature sensor(s) suspended in the respective flow-slot. These sensors are positioned to measure the temperature of the fluid exiting the respective flow-slot more accurately. A smart master controller may monitor a selected set of the flow slot temperature sensors, and coordinates the activities of all active flow-slot valve controllers.[234] The 2012 Provisional also discloses attaching a solid-state temperature sensor on or adjacent to each supplemental spray head to provide closed-loop control of the valves supplying the spray head.[235]

218. In addition to other concepts, the 2012 Provisional also discloses a system with forced fluid convection. In operation, cold fluid flows into a tank via a tube connected to a slotted

[233] *Id.* at MIDAS0004055-4056.
[234] *Id.* at MIDAS0004055-4056.
[235] *Id.* at MIDAS0004058.

manifold. The slots in the manifold may be holes. The cold fluid displaces warm fluid as it flows into the tank. The warm fluid overflows from U-shaped tubes on both sides of the tank wall. The U-shaped tubes drain warm fluid into a closed sump container for recirculation through a heat exchanger.[236] The 2012 Provisional explains that to prevent loss of pressure the slots or holes of the slotted outflow manifold may be progressively wider. [237] As discussed in the Background of Technology, a manifold is a common component in a flow distribution system. A person skilled in the art of flow management, as used for example in HVAC systems, would know that achieving uniform flow leaving the supply manifold through the slots or orifices requires skill in selection of the relative size of the main manifold cross-sectional area, and the cross-sectional area of the orifices. The 2012 Provisional is misleading because increasing the size of the orifice or slot to make it progressively larger may in fact make flow uniformity worse.

219. The 2012 Provisional further discloses an air containment system for cooling equipment that cannot be immersed in liquid coolant. The system is depicted below:[238]



[236] *Id.* at MIDAS0004082.
[237] *Id.* at MIDAS0004082.
[238] *Id.* at MIDAS0004088-90.

"a plenum, positioned adjacent the bottom of the tank, adapted to dispense the dielectric fluid substantially uniformly upwardly through each appliance slot."

220. Based on my review, it is my opinion that the 2012 Provisional does not disclose to a POSA the existence of the following limitation of the Asserted Patents:

> "a plenum, positioned adjacent the bottom of the tank, adapted to dispense the dielectric fluid substantially uniformly upwardly through each appliance slot."

221. In particular, the 2012 Provisional does not disclose a structure for dispensing liquid or plenum that is adapted to dispense dielectric fluid "substantially uniformly upwardly." The 2012 Provisional describes that the spray head(s) are distributed in a radial arrangement so the flow of dielectric fluid resembles a fan.[239] It further identifies that supplemental spray bars may be added and oriented vertically with "horizontally-oriented" spray head(s).[240] These horizontally-oriented and radially-arranged spray heads would not dispense dielectric fluid in "substantially uniformly upwardly" as recited in the Asserted Claims. As such, the 2012 Provisional does not disclose to a POSA a plenum or structure for dispensing liquid that is adapted to dispense dielectric fluid substantially uniformly upwardly.

222. In addition, it is my opinion that the 2012 Provisional's disclosed arrangement of spray heads does not teach this limitation such that a POSA could practice the purported invention of the Asserted Patents without undue experimentation. Specifically, the 2012 Provisional teaches that multiple spray bars and spray heads share dielectric fluid flowing in interconnected piping. This causes the flow rate of one spray head to impact (i.e., reduce or increase) the flow rate of another spray head. Consequently, setting the flow rate of each spray head to be equal would cause spray heads closest to the supply of dielectric fluid to have substantially increased flow rates compared to spray heads further away from the supply of dielectric fluid.

223. Furthermore, although the 2012 Provisional teaches that spray heads can have fixed flow rate or variable flow rate,[241] the disclosure does not teach the goal of uniform upward flow or how to achieve it. It does not teach how to fix or vary the flow rate of spray heads in order to dispense the dielectric fluid "substantially uniformly upwardly." As such, a POSA would be forced to undertake unguided attempts of trial and error with an exceedingly large number of variables in an attempt to achieve "substantially uniformly upwardly" dispensing of the dielectric fluid.[242] As a result, a POSA would not be able to achieve dispensing dielectric fluid "substantially uniformly upwardly" without undue experimentation.

224. The 2012 Provisional also mentions in handwritten notes and diagrams "slotted outflow manifold[s]" with gaps between the manifolds.[243] To the extent the slotted outflow manifold could constitute a plenum, it fails to describe or teach a POSA how to accomplish "substantially

[239] *Id.* at MIDAS0004057.
[240] *Id.* at MIDAS0004057.
[241] *Id.* at MIDAS0004057-4058.
[242] *See* Sickmiller Dep. 241:21-247:1, Nov. 29, 2023.
[243] 2012 Provisional at MIDAS0004082.

uniformly upwardly" of dielectric fluid. Achieving uniform flow requires precise selection of the relative size of the slots of the outflow manifold. Indeed, the 2012 Provisional gets the applicable principles exactly backwards when it states that the holes of the manifold should be narrow closest to where the coolant enters and should get progressively wider to account for pressure getting lower as coolant flows down the tube.[244] The holes should be wider near the entrance because the pressure is lower near the entrance and the fluid velocity is higher. As the flow slows across the length of the tube, one could then make holes smaller to increase the pressure. But even so, to achieve substantially uniform upward flow through each appliance slot, there must be some way both to make the fluid flow turn upwards and to guarantee that it is uniform. That is difficult to do, and the 2012 Provisional does not even comment on the problem, much less propose a solution to it. The plenum (or settling chamber) would have to be designed carefully to achieve substantially uniform upward flow—among other things, it would have to have adequate volume to allow the fluid to distribute itself and settle—that is, to lose the velocity with which it entered the plenum so that uniform upward flow would then be possible. The 2012 Provisional says nothing at all about the proposed design of any plenum, nor about the vertical placement of the slotted outflow manifold within the tank. As a result, a POSA would not be able to achieve dispensing dielectric fluid "substantially uniformly upwardly" without undue experimentation.

225. Underlining the lack of any supporting disclosure, the plenum structure depicted in the '457 and '446 patents is entirely absent from the 2012 Provisional, and the 2012 Provisional does not use the word plenum. The plenum as taught in the '457 and '446 patents is not disclosed in the 2012 Provisional such that it is evident the inventors did possess this element of the invention as of the 2012 Provisional.

226. I understand that Christopher Boyd, one of the named inventors on the Asserted Patents, testified that he believed it was obvious to place the plenum at the bottom and center of the tank to produce even flow across the bottom.[245] I agree that that placement would have been obvious, and that the claim limitations reciting a plenum positioned adjacent the bottom of the tank and adapted to dispense the dielectric fluid substantially uniformly upwardly through each appliance slot were obvious in view of the prior art (and in particular in view of the Best Tank, which Mr. Boyd used and worked with for more than a year before he began to develop his alleged invention, and which contained a plenum positioned adjacent the bottom of the tank and adapted to dispense the dielectric fluid substantially uniformly upwardly through each appliance slot at least to the same extent disclosed in the patent—which again, does not teach how to achieve substantially uniform upward flow through each appliance slot).

227. Therefore, it is my opinion that the 2012 Provisional fails to teach a structure for dispensing liquid or plenum that dispenses the dielectric fluid "substantially uniformly upwardly" such that a POSA could practice the purported invention without undue experimentation.

[244] *Id.*
[245] *See, e.g.*, Boyd Dep. 229:16-235:8, Dec. 7, 2023.

"a weir, integrated horizontally into the long wall of the tank adjacent all appliance slots, having an overflow lip adapted to facilitate substantially uniform recovery of the dielectric fluid flowing through each appliance slot."

228. Based on my review, it is also my opinion that 2012 Provisional does not disclose to a POSA the existence of the following limitation of the Asserted Patents:

> "a weir, integrated horizontally into the long wall of the tank adjacent all appliance slots, having an overflow lip adapted to facilitate substantially uniform recovery of the dielectric fluid flowing through each appliance slot."

229. The 2012 Provisional describes a weir as follows:[246]

[0010] 2. The Spray Bars are spaced such that a Server may be suspended in each inter-Spray Bar gap, thus forming respective 'flow slots' the flow patterns of which project upward from the Spray Heads, through the inter-Server gaps, and, ultimately into open fluid return channel(s) (e.g., weirs) extending horizontally along the long side(s) of the tank.

230. I understand that MGT has asserted and maintained that the Asserted Claims require a weir that is "adjacent all appliance slots."[247] The only portion of the 2012 Provisional that discusses the location of the weir in relation to the appliance slots (i.e., "flow slots"), states that once the fluid in the tank exits the inter-server gaps, it flows "into open return channel(s) (e.g., weirs) extending horizontally along the long side(s) of the tank."

231. This statement does not disclose that the weir must be "adjacent all appliance slots" or extend[] substantially the entire length of the tank. To the contrary, it only discloses that the weir is on the long wall of the tank—a criticism that MGT has asserted with respect to the prior art.[248] In addition, the phrase "open return channel(s) (e.g., weirs)" implies that there is not a single weir that is "adjacent all appliance slots."

232. The 2012 Provisional also mentions in handwritten notes and diagrams "slotted outflow manifold[s]" with gaps between the manifolds, as described below.[249]

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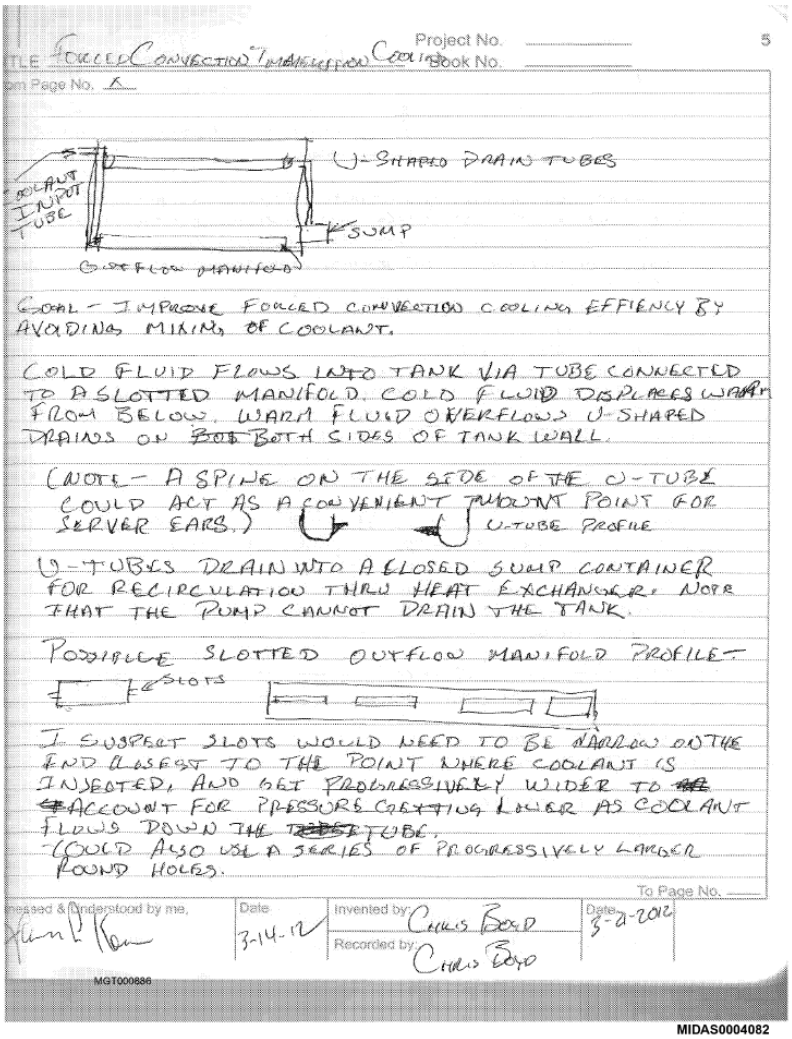
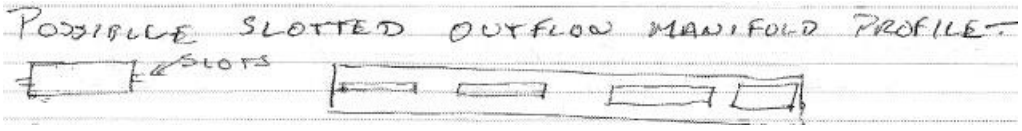
[246] 2012 Provisional at MIDAS0004055.
[247] *See, e.g.*, January 31, 2017 Office Action Response, MIDAS0003334 at MIDAS0003483-3488; Patent Owner's Preliminary Response at 4 ("The weir (22) extends to substantially the entire length of the tank, adjacent all the appliance slots.").
[248] *Id.*
[249] 2012 Provisional at MIDAS0004082.



233. The notes, however, do not mention the location of appliance slots in the tank, and so also do not mention the location of the slotted outflow manifold in relation to the appliance slots. Rather, the notes appear to disclose that there could be multiple slotted outflow manifolds or progressively larger holes, and therefore no single weir that is "adjacent all appliance slots."[250]

234. In any event, the slotted outflow manifold is described in relation to cold coolant input and as such does not describe the structure or function of a weir, as discussed above.

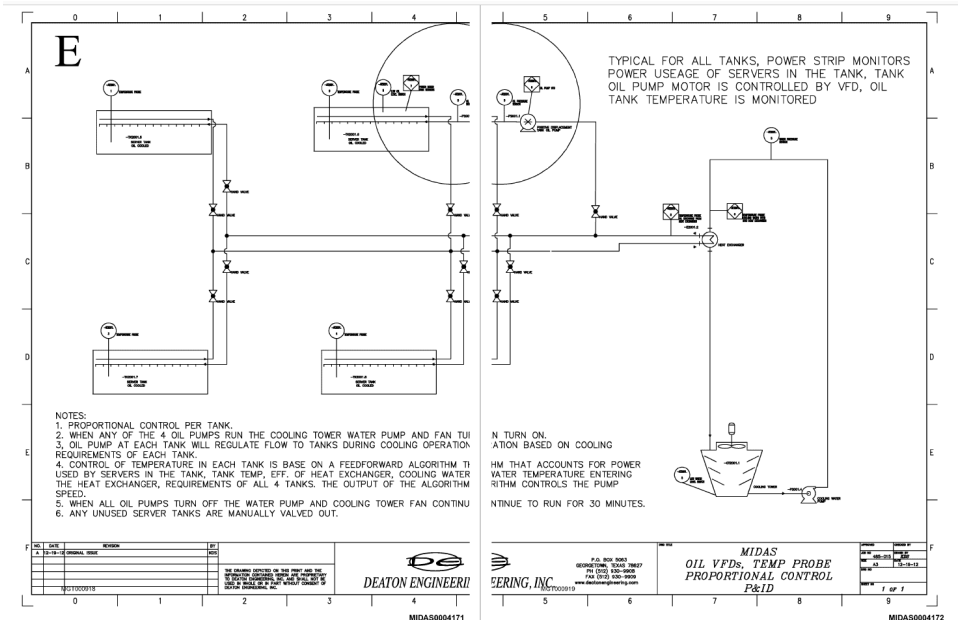


235. It is therefore my opinion that the 2012 Provisional does not disclose to a POSA a weir "adjacent all appliance slots" as recited in the Asserted Claims or how to make such a weir without undue experimentation.

[250] *Id.* at MIDAS0004082.

The 2013 Provisional

236. The 2013 Provisional lists as inventors, John H. Miller Jr.; James P. Koen; John C. Tribou; Mike Rainone; Talbot Presley; Jeffrey Van Myers; Christopher L. Boyd; Kenneth D. Tooke; and D. Christopher T. Laguna.[251] It discloses various proportional control piping and instrumentation diagrams drafted by Deaton Engineering.



237. The diagrams provide that the disclosed tank's pump and cooling tower fan speed are controlled by a variable frequency drive ("VFD"). The tank oil temperature and discharge oil temperature are also monitored. In particular, the temperature of the oil in a tank is based on a feedforward algorithm that accounts for power used by servers in the tank, the tank's temperature, the effect of heat exchangers, the temperature of cooling water entering the heat exchangers, and the requirements of all 4 tanks. The output of the algorithm controls the pump's speed.[252]

238. These diagrams do not describe or depict a weir, or more particularly, "a weir, integrated horizontally into the long wall of the tank adjacent all appliance slots, [having an overflow lip] adapted to facilitate substantially uniform recovery of the dielectric fluid flowing through each appliance slot," "a dielectric fluid recovery reservoir positioned vertically beneath the overflow lip of the weir," or "a plenum, positioned adjacent the bottom of the tank, adapted to dispense the dielectric fluid substantially uniformly upwardly through each appliance slot." It is thus my opinion that the 2013 Provisional does not disclose to a POSA all of the limitations of the Asserted Claims.

239. It is therefore my opinion that the 2012 Provisional and the 2013 Provisional do not disclose to a POSA all of the limitations of the Asserted Claims of the Asserted Patents.

[251] 2013 Provisional at MIDAS0004155.
[252] *Id.* at MIDAS0004163-4176.

ANTICIPATION

Opinions Regarding the '457 Patent

240. I have read and analyzed the '457 patent against the prior art. Based on my review of the prior art, and in light of the parties' Joint Stipulation on Claim Construction as well as MGT's interpretation of the Asserted Claims in its Final Infringement Contentions, it is my opinion that every limitation recited in the Asserted Claims of the '457 Patent is included, either explicitly or inherently, in Best '463, Best Publication, Best Tank, and Best '914 (collectively, the "Best References"). My full analysis of these prior art references is presented in the claim charts attached hereto as **Exhibits D-1** through **D-9**. Below is a summary of my analysis. My analysis with regard to Best '463 also applies to Best '914, as these references share a common disclosure.[253] Similarly, my analysis of Best Publication applies equally to the Best Tank, as the Best Tank is an embodiment of the Best Publication.[254]

Independent Claims

Claim 1

Limitation 1.P: "An appliance immersion cooling system comprising:"

241. I have not been asked to consider whether the preamble of claim 1 is limiting. To the extent the preamble is limiting, it is my opinion that the Best References each teach an appliance immersion cooling system.

242. As aforementioned, immersion cooling systems are well known in the prior art. The '457 patent specifically identifies Best '463 as one such system.[255] The Best Publication, Best Tank, and Best '914 are similarly directed to or embody apparatus, systems, and methods for cooling computing devices immersed or submerged in a dielectric liquid coolant.[256]

243. It is thus my opinion that, to the extent the preamble is limiting, its limitations are disclosed or embodied in the Best References.

Limitation 1.1: "a tank adapted to immerse in a dielectric fluid a plurality of electrical appliances, each in a respective appliance slot distributed vertically along, and extending transverse to, a long wall of the tank, the tank comprising:"

244. It is my opinion that the Best References each teach a tank as recited in limitation 1.1 of the '457 patent.

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[253] *See* Best '914 at [63].
[254] Best Decl.¶¶ 6-9; Pl.'s Supp. Resp. to Defs.' Interrog. No. 13, Mar. 15, 2023 at 5; Boyd Dep. 219:11-18; 220:14-222:23, Dec. 7, 2023.
[255] '457 patent at 2:23-29.
[256] *See, e.g.*, Best '463 at [57], 4:31-35, Fig. 11; Best '914 at [57], 4:29-33, Fig. 11; Best Publication at [57], [0003], [0016]-[0017], Fig. 6; RHOD0000907; TACC00000065 at slide 4.

Best '463/Best '914

245. Best '463 and Best '914 each teach or embody a tank adapted to immerse in a dielectric fluid a plurality of electrical appliances.[257] Best '463 and Best '914 teach "novel apparatus, systems, and methods for efficiently cooling computing devices having heat-generating electronic components, such as, for example, independently operable servers immersed in a dielectric liquid coolant in a tank."

246. The interior of the tank consists of mounting members "positioned within the interior volume" that correspond to appliance slots.[258] The mounting members are "configured to mountably receive a plurality of independently operable servers" and "are configured to mountably receive the plurality of servers in a vertical orientation."[259]

247. Best '463 and Best '914 each further disclose that the servers are in slots distributed vertically along, and extending transverse to, a long wall of the tank, the tank. Specifically, Best '463 and Best '914 teach that the mounting members may be attached along the length (L) of each longer side of the tank to support the rack ears of a standard rack-mountable server" and illustrate that the mounting members extend transverse to a long wall of the tank. For example, Figures 4, 6, and 11 of Best '463 and Best '914 illustrate a top and side view of the racks of the disclosed tank. As depicted in Figure 6, below, a plurality of servers (120) mounted in mounting members are vertically distributed along the length (L) of the tank.[260]

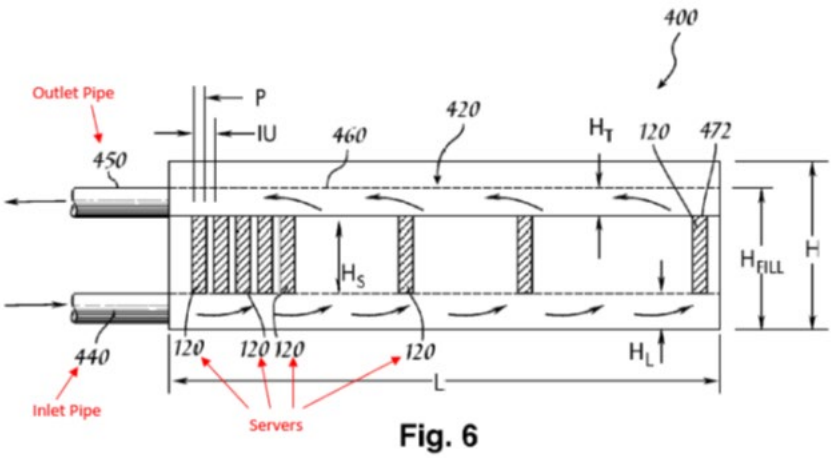


Figure 6 (annotated).

[257] *See, e.g.*, Best '463 at 5:3–11, 10: 11–25; Best '914 at 5:1–9, 10:7–22.
[258] *See, e.g.*, Best '463 at 6:29–35, 18:1–11; Best Publication at cl. 1, [0041], [0068], Fig. 6; Best '914 at 6:27–33, 7:64–18:19; RHOD0000899.
[259] *See, e.g.*, Best '463 at 18:35–38; Best Publication at Fig. 3; Best '914 at 8:33–36; RHOD0000805, RHOD0000899.
[260] *See, e.g.*, Best '463 at Figs. 4, 6, 7:37-43, 14:21-38, 14:48-57; Best '914 at Figs. 4, 6, 7:35-40, 14:18-36, 14:44-54.

248. It is my understanding that during prosecution of the application for the '457 patent, the examiner also relied on Figures 6 and 11 for concluding that Best '463 discloses appliance slots,[261] and Figures 3 and 4, particularly citing to "L" within the Figures in relation to servers 120, to identify the slots in Best '463 as distributed vertically along and extending transverse to the long wall of the tank.[262] I understand that MGT did not traverse the examiner's rejection with respect to these conclusions or otherwise distinguish the appliance slots in the Asserted Claims from the appliance slots in Best '463. MGT similarly did not distinguish the appliance slots in the Asserted Claims from the appliance slots in Best '463 during the IPR and PGR proceedings.[263]

Best Publication/Best Tank

249. Best Publication and Best Tank each teach or embody a tank adapted to immerse in a dielectric fluid a plurality of electrical appliances.[264] Best Publication teaches an "apparatus, system, and method of cooling one or more hard disk drives [("HDD")] of one or more computing systems." "The apparatus, system, and method use a dielectric liquid coolant in a tank that has an interior volume" and "mounting members may be configured to allow the one or more computing systems to be at least partially submerged within the dielectric liquid coolant when the dielectric liquid coolant is in the interior volume for sufficiently cooling the one or more computing systems."[265] Best Tank consists of a tank that "fully submerges [servers] in GreenDEF non-conductive coolant,"[266] a type of dielectric fluid.

250. Best Publication and Best Tank each further disclose and depict that the servers are in a respective appliance slot distributed vertically along, and extending transverse to, a long wall of the tank.

[261] '457 Patent Prosecution History at MIDAS0003497-99.
[262] *Id.*
[263] *See generally*, *Immersion Systems LLC v. Midas Green Technologies, LLC*, No. IPR2021-01176 (P.T.A.B. June 23, 2021); *Immersion Systems LLC v. Midas Green Technologies, LLC*, PGR2021-00104 (PTAB July 26, 2021).
[264] *See, e.g.*, Best '463 at 5:3–11, 10: 11–25; Best Publication at [0042]; RHOD0000907; TACC00000065 at slide 4; Best '914 at 5:1–9, 10:7–22.
[265] Best Publication at [0017].
[266] Design - Green Revolution Cooling at RHOD0000899.

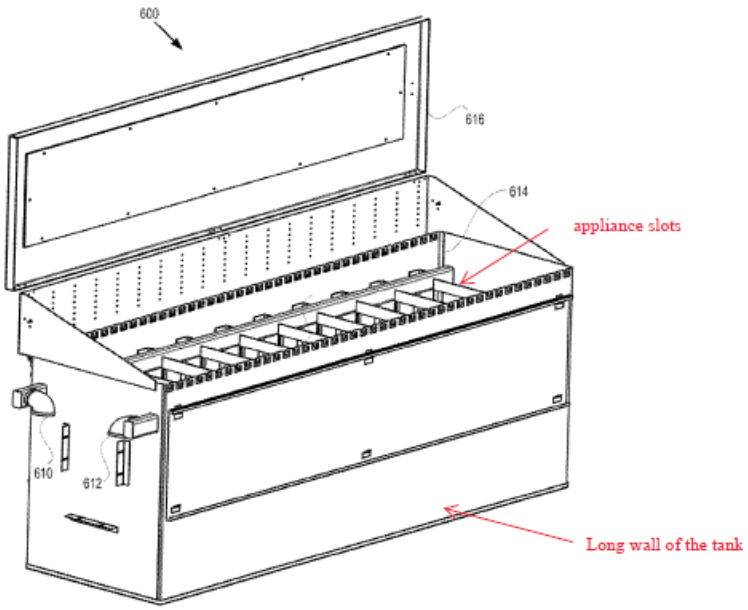


FIG. 6

Figure 6 (annotated)

251. Best Publication explains that "[b]oth the computing systems and HDDs may be arranged in one or more racks."[267] "A rack is a frame or enclosure that contains multiple mounting slots called bays, each designed to hold a hardware unit secured in place with fastening devices such as screws."[268] "The interior volume of the tank 600 includes a rack system 614 for holding the computing systems 230 and HDDs 240."[269]

[267] Best Publication at [0041].
[268] *Id.*
[269] *Id.* at [0068].

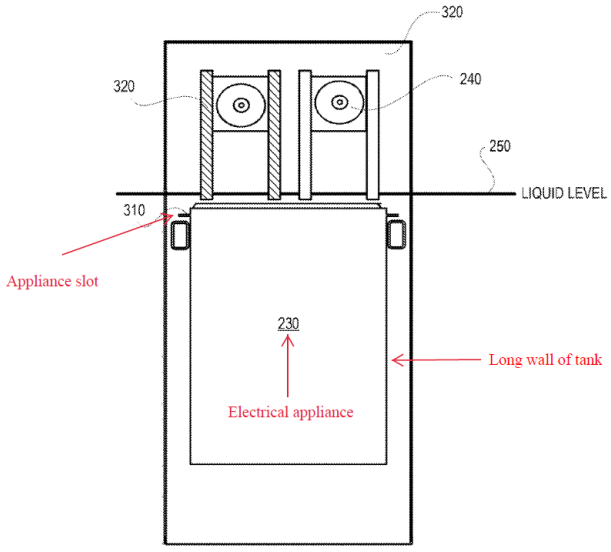
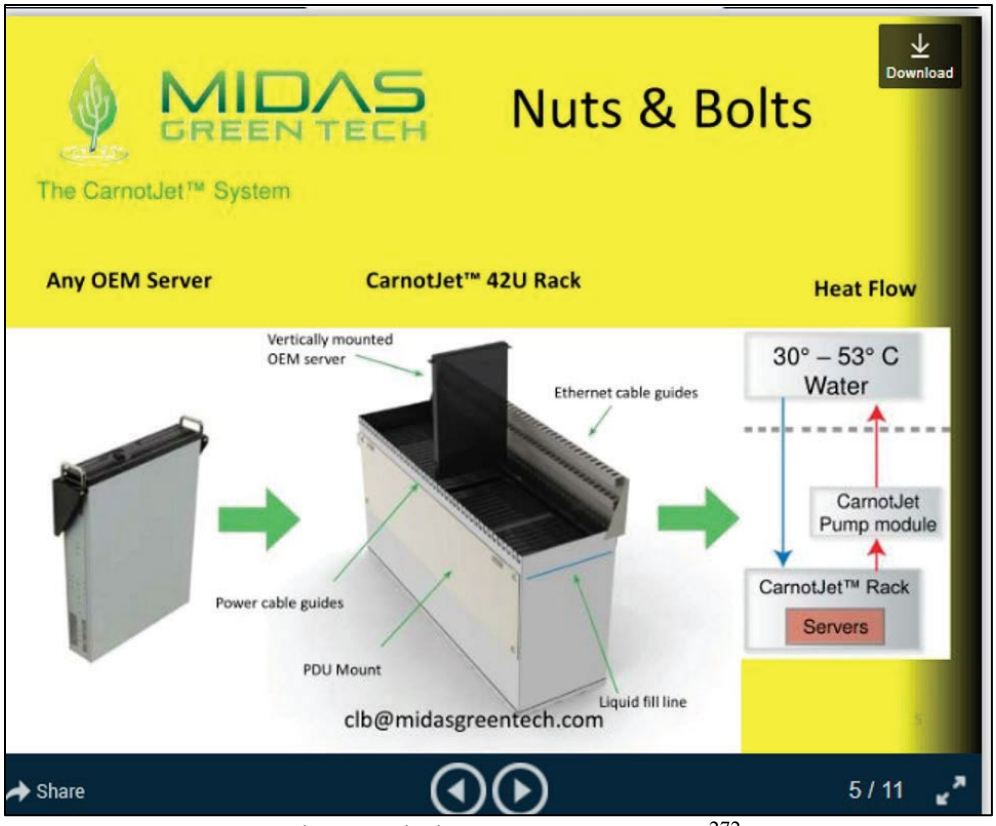


Figure 3 (annotated).

252. Figure 6 of the Best Publication depicts "a rack system 614 for holding the computing systems 230 and HDDs 240" in which servers are positioned vertically along the length of the tank, as further depicted in Figure 3.[270] "Computing system 230 which may include motherboard, power supply and other components may be fastened to the part of the mounting plate 300 that is

[270] *See, e.g.*, Best Publication at [0029], [0044], Fig. 6.

submerged in the dielectric liquid coolant using any of various methods (e.g., screws, slots, rails etc.).”[271]



Presentation Depicting CarnotJet System[272]

253. Best Tank “accepts servers vertically rather than horizontally.” As depicted above, the vertically mounted servers are slotted along the interior of the tank’s length, extending transverse to the long walls of the tank.[273]

254. It is thus my opinion that the Best References each disclose or embody limitation 1.1.

[271] *Id.* at [0044].
[272] *See, e.g.*, RHOD0001042.
[273] *See also* RHOD0000907; RHOD0000801; RHOD0000813; TACC00000065 at slide 4.

Limitation 1.2: "a weir, integrated horizontally into the long wall of the tank adjacent all appliance slots, having an overflow lip adapted to facilitate substantially uniform recovery of the dielectric fluid flowing through each appliance slot;"

255. It is my understanding that the parties have agreed to a claim construction of the term "weir" as follows: "an overflow structure or barrier that determines the level of liquid."[274] I have considered and used this construction in my analysis and opinions.

256. I also understand that during prosecution of the application for the '457 patent, MGT sought to differentiate the Pfahnl Application by asserting that "in Pfahnl, each of the openings 122 into the [outlet] plenum 112 is disposed adjacent only to a respective single ONE of the appliance slots, and none is disposed adjacent to ALL of the appliance slots."[275] It is thus my understanding that MGT has argued that the weir itself must be "adjacent all appliance slots"—and not merely "integrated horizontally into the long wall of the tank" that is "adjacent all appliance slots"— in order to obtain allowance of the Asserted Claims.

257. I further understand that in its infringement contentions, MGT has identified openings or "holes" in the accused products as meeting the elements of limitation 1.2.[276] I do not agree with MGT's analysis, and will provide my reasoning at a later time. Nevertheless, under MGT's interpretation of the claim scope as reflected in its Final Infringement Contentions, it is my opinion that the Best References each teach or embody the elements recited in limitation 1.2.

Best '463/Best '914

258. Best '463 and Best '914 each teach "a weir, integrated horizontally into the long wall of the tank adjacent all appliance slots, having an overflow lip adapted to facilitate substantially uniform recovery of the dielectric fluid flowing through each appliance slot."

259. Best '463 and Best '914 describe an "outlet pipe or line 450 connected to collection piping for flowing or pumping of heated coolant out of the tank to the external heat exchanger."[277] As depicted in Figure 3 of Best '463 and Best '914 the outlet pipe serves as an overflow structure that determines the level of the liquid as it is a pipe or line (*i.e.* a structure) integrated into a wall of the tank. As discussed in the Background of Technology, specifically in reference to Figure 15, an outlet pipe may establish the level of the free surface at appropriate rates of flow. The outlet pipe determines the level of the tank liquid because the pipe serves as an overflow device, as shown in Figure 15, wherein the liquid level is at the same level as the outflow pipe. It is thus my opinion that this outlet pipe meets the agreed to construction of the term "weir."

[274] Joint Stipulation on Claim Construction, ECF No. 50.
[275] '457 Patent Prosecution History at MIDAS0003487-3488 (emphasis in original).
[276] Final Infringement Contentions at 6-7.
[277] Best '463 at 14:40-45.

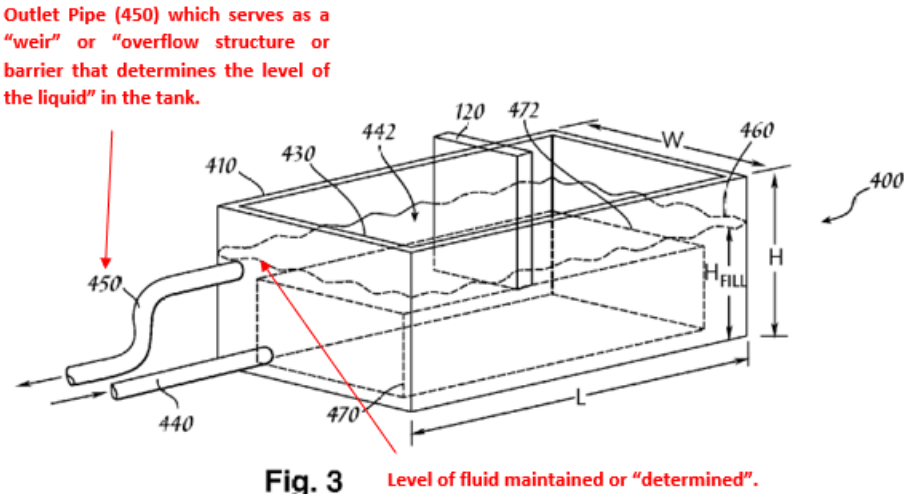


Figure 3 (annotated).

260. In one embodiment, Best '463 and Best '914 disclose that the outlet piping is integrated horizontally into the long wall of the tank adjacent all appliance slots. Best '463 and Best '914 identify a configuration wherein "the outlet piping 650 is located nearer the opposite end of the same longer side of the rectangular tank nearer the top of the tank."[278] Best '463 and Best '914 further teach that the outlet piping has an overflow lip adapted to facilitate substantially uniform recovery of the dielectric fluid flowing through each appliance slot. As discussed above, the outlet piping of Best '463 and Best '914, in my opinion, constitutes a weir and thus also meets the construction of a weir having an overflow lip. In addition, the bottom of the outlet pipe constitutes an "overflow lip."

261. The arrangement of the plenum in Best '463 and Best '914 (as will be discussed below), with the appliance slots and outlet piping in Best '463 facilitates substantially uniform recovery of dielectric fluid flowing through each slot. For example, Best '463 and Best '914 identify substantially uniform flow throughout the tank as they state:

> The mounting members may also be configured to mount the servers such that the top level 460 of liquid coolant completely submerges the top level 472 of the server rack [] formed by the multiple servers 120. As a consequence, ***a volume of liquid coolant collects in a common manifold area above the server rack [] to improve the circulation of the liquid coolant through the plurality of servers, thereby enhancing the cooling of each respective server***. The mounting members may also be configured to mount the servers in server rack [] above the bottom of the tank to create a volume of liquid coolant between each respective server and the bottom of the tank ***such that the flow of the dielectric liquid coolant through the servers is improved***. Preferably, the mounting members are configured to mount the servers closely adjacent to one another in the server rack to restrict the flow of the dielectric liquid coolant

[278] *Id.* at 16:26-29 (emphasis added).

> between the vertically-oriented servers, ***such that the flow of the dielectric liquid coolant through the servers is enhanced***.[279]

262. Best '463 and Best '914 further describe that there is substantially uniform recovery of the fluid as it exits the tank because "the liquid coolant may flow through each installed server and exit through the outlet pipe from the tank" and "[b]ecause the flow is relatively low in comparison to the total volume of the container, the fluid conducts to be relatively uniform temperature."[280]

263. In my opinion, relatively uniform temperature would not be possible without substantially uniform recovery of dielectric fluid flowing through each appliance slot. Best '463 and Best '914 describe how substantially uniform flow and substantially uniform recovery is achieved due to the (a) volume of liquid coolant between each server and the bottom of the tank, (b) the mounting of servers closely adjacent to restrict the flow of dielectric liquid coolant, (c) the volume of liquid collected in the common manifold in the area above the servers rack, (d) an outlet pipe that may be integrated into the long wall adjacent the appliance slots recovering the volume of liquid in the common manifold in the area above the servers, and (e) the relatively low flow in comparison to total volume of the tank.[281]

264. Best '463 and Best '914 thus disclose a system with substantially uniform recovery, including by virtue of the arrangement of its plenum, appliance slots, flow rate, and inclusion of a space above the appliance slots before the weir to create a layer of hot dielectric fluid to mix as it exits the appliance slots.

Best Publication/Best Tank

265. Under MGT's interpretation of the claim scope as reflected in its Final Infringement Contentions, the Best Publication and Best Tank teach or embody "a weir, integrated horizontally into the long wall of the tank adjacent all appliance slots, having an overflow lip adapted to facilitate substantially uniform recovery of the dielectric fluid flowing through each appliance slot."

[279] Best '463 at 14:58-15:8 (emphasis added).
[280] *Id.* at 19:36-47.
[281] *Id.* at 14:58-15:8; 19:36-47; Figs. 3, 6, 11.

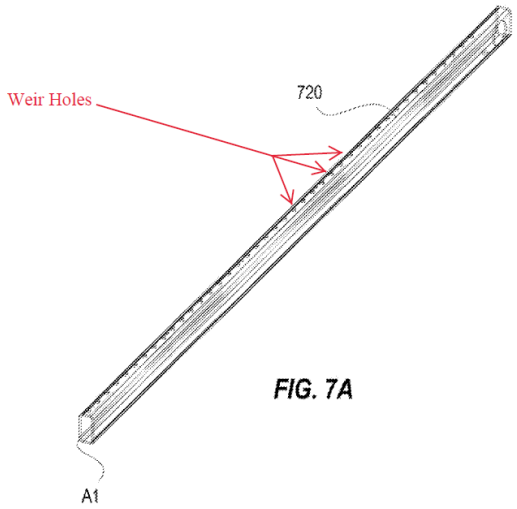


Figure 7A (annotated).

266. Best Publication teaches the use of an "overflow structure or barrier that determines the level of the liquid." It describes a plurality of nozzles distributed along the length of a suction manifold to facilitate the flow of warmer dielectric liquid out of the interior volume of the tank.[282] The nozzles have an area, which would form holes in the suction manifold,[283] and thus allow dielectric fluid to flow into the suction manifold.[284] The nozzles of the suction manifold thus serves as a weir or "an overflow structure or barrier that determines the level of liquid."

[282] Best Publication at [0023], [0069], cls. 8, 16, 26.
[283] *Id.* at [0069].
[284] *Id.* at [0070].

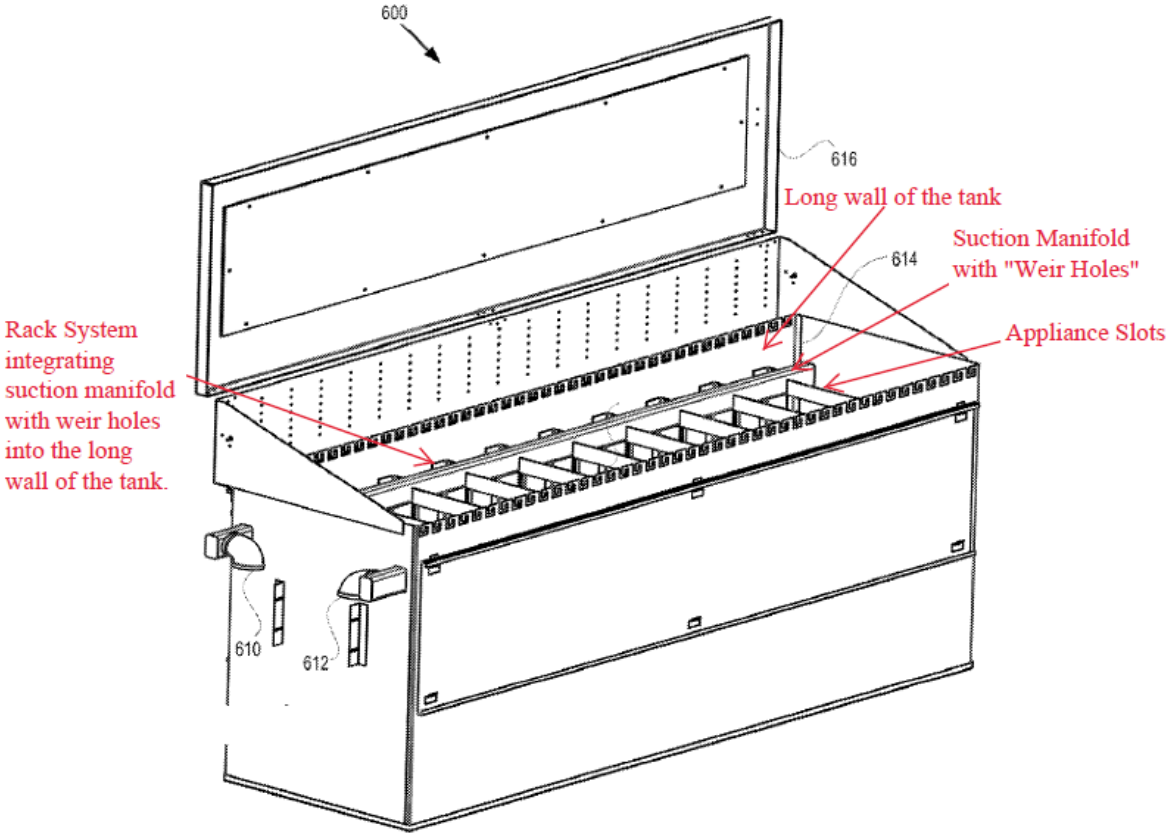


FIG. 6

Figure 6 (annotated).

267. The Best Publication further teaches that the nozzles of the suction manifold are integrated horizontally into the long wall of the tank adjacent all appliance slots.[285] For example, Figure 6 depicts an exemplary tank as taught by the Best Publication. In the embodiment, the suction manifold runs horizontally along the entire length of the tank,[286] and is integrated into the tank wall by a rack system.[287] The nozzles are distributed along the entire length of the suction manifold,[288] and thus are also adjacent all the vertical mounting slots, discussed above.[289]

268. The Best Publication further teaches that the nozzles of the suction manifold have an overflow lip adapted to facilitate substantially uniform recovery of the dielectric fluid flowing through each mounting slot. As aforementioned, the nozzles have an area.[290] The edges of the area

[285] *Id.* at [0041].
[286] *Id.* at [0070].
[287] *Id.* at [0068]-[0069].
[288] *Id.* at [0069].
[289] *Id.* at Fig. 6.
[290] *See id.* at [0069].

of the nozzles constitute an overflow lip as it allows dielectric fluid to flow into the suction manifold.[291] The Best Publication explains that because the area of the nozzles is much smaller than the area of the suction manifold, suction through the nozzles of the suction manifold is approximately equal along the entire length of the tank.[292] The equal suction along the length of the tank would facilitate substantially uniform recovery of the dielectric fluid through each mounting slot.

269. Therefore, it is my opinion that the nozzles of the suction manifold described in the Best Publication satisfy limitation 1.2 of the '457 patent.

270. I understand that the Best Tank also includes a suction manifold with holes through which the warm dielectric fluid leaves the tank, as described above with respect to the Best Publication.[293]

271. It is thus my opinion that, under MGT's interpretation of the claim scope as reflected in its Final Infringement Contentions, the Best References each disclose or embody limitation 1.2.

Limitation 1.3: "a dielectric fluid recovery reservoir positioned vertically beneath the overflow lip of the weir and adapted to receive the dielectric fluid as it flows over the weir;"

272. Under MGT's interpretation of the claim scope as reflected in its Final Infringement Contentions, it is my opinion that the Best References each teach or embody the elements recited in limitation 1.3.

Best '463/Best '914

273. Best '463 and Best '914 disclose "a dielectric fluid recovery reservoir positioned vertically beneath the overflow lip of the weir and adapted to receive the dielectric fluid as it flows over the weir" as recited in limitation 1.3.

274. In particular, Best '463 and Best '914 describe "a heat exchanger fluidly coupled to the coolant outlet of the at least one tank,"[294] and "[t]he tank may be fabricated to have … an outlet pipe or line connected to collection piping for the flowing or pumping of heated coolant out of the tank to the distally located heat exchanger as shown in FIG. 3."[295]

275. Figure 3 of Best '463 and Best '914 further indicates that the outlet piping extends at a downward angle or turn utilizing gravity to remove the warm dielectric from the tank into the heat exchanger. Therefore, the heat exchanger is "positioned vertically beneath the overflow lip of the weir." As such, the heat exchanger in Best '463 and Best '914 is a reservoir to collect the heated dielectric fluid, and therefore is a "dielectric fluid recovery reservoir … adapted to receive the dielectric fluid as it flows over the weir."

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[291] *Id.* at [0070].
[292] *Id.* at [0070].
[293] Best Decl. ¶¶ 8-9; Pl.'s Supp. Resp. to Defs.' Interrog. No. 13, Mar. 15, 2023 at 5; Boyd Dep. 219:11-18; 220:14-222:23, Dec. 7, 2023.
[294] Best '463 at 4:45-46.
[295] *Id.* at 18:23-29.

276. It is thus my opinion that the heat exchanger in Best '463 and Best '914 is a reservoir to collect the heated dielectric fluid, and therefore is a "dielectric fluid recovery reservoir … adapted to receive the dielectric fluid as it flows over the weir."

Best Publication/Best Tank

277. The Best Publication discloses "a dielectric fluid recovery reservoir positioned vertically beneath the overflow lip of the weir." As aforementioned, the Best Publication discloses nozzles of a suction manifold that meet the construed meaning of a weir.[296] The edges of the area of the nozzles constitute an overflow lip as it allows dielectric fluid to flow into the suction manifold.[297] The suction manifold serves as a dielectric fluid recovery reservoir and receives the dielectric fluid as it flows over the nozzles.[298] As depicted in Figures 7A and 6, the nozzles are distributed along the length of the top of the suction manifold.[299] The suction manifold is attached to a fluid outlet to facilitate the flow of warmer dielectric liquid out of the interior volume,[300] and "a pump may be used to pump warmer dielectric liquid coolant from the interior volume of the tank."[301]

278. Therefore, it is my opinion that the nozzles and suction manifold described in the Best Publication satisfy limitation 1.3 of the '457 patent.

279. As aforementioned, I understand that the Best Tank also includes a suction manifold with holes through which the warm dielectric fluid leaves the tank.[302] For the reasons described above with respect to the Best Publication, the Best Tank's suction manifold and holes also satisfies limitation 1.3.

280. It is thus my opinion that under MGT's interpretation of the claim scope as reflected in its Final Infringement Contentions the Best References each disclose or embody limitation 1.3.

Limitation 1.4: "a primary circulation facility adapted to circulate the dielectric fluid through the tank, comprising:"

281. It is my opinion that the Best References each teach or embody the elements recited in limitation 1.4.

Best '463/Best '914

282. Best '463 and Best '914 disclose the use of additional structures as part of a primary circulation facility, such as pumps, to assist in circulating the dielectric through the tank and system. Best '463 and Best '914 state "[a] pump, such as pump 330 in FIG. 2, may pump liquid

[296] *See* Best Publication at [0069].
[297] *Id.* at [0070].
[298] *Id.* at [0070].
[299] *Id.* at Figs. 6, 7A, [0069].
[300] *Id.* at [0069].
[301] *Id.* at [57], [0023], [0053], cls. 7-8, 16-17, 25-26.
[302] *See* Best Decl. ¶¶ 8-9; Pl.'s Supp. Resp. to Defs.' Interrog. No. 13, Mar. 15, 2023 at 5; Boyd Dep. 219:11-18; 220:14-222:23, Dec. 7, 2023.

coolant from the external heat exchanger through the piping system into the tank 410 to maintain coolant fluid circulation within the tank."[303] The figures, including Figures 1A, 1B, and 2, also depict the flow path of the dielectric fluid within the primary circulation facility of Best '463 and Best '914.

Best Publication/ Best Tank

283. The Best Publication discloses "a primary circulation facility adapted to circulate the dielectric fluid through the tank," specifically a pump for pumping cooler dielectric liquid coolant into the interior volume of the tank.[304] Therefore, it is my opinion that the pump described in the Best Publication satisfies limitation 1.4 of the '457 patent.

284. I understand that the flow of the dielectric fluid in the Best Tank is described in paragraphs [0069] through [0073] of the Best Publication.[305] Furthermore, the Best Tank is described as consisting of a pump module responsible for cooling and recirculating coolant through the tank.[306]

285. It is thus my opinion that the Best References each disclose or embody limitation 1.4.

Limitation 1.5: "a plenum, positioned adjacent the bottom of the tank, adapted to dispense the dielectric fluid substantially uniformly upwardly through each appliance slot."

286. Under MGT's interpretation of the claim scope as reflected in its Final Infringement Contentions, which I disagree with, it is my opinion that the Best References each teach or embody the elements recited in limitation 1.5.

287. It is my understanding that the parties have agreed to a claim construction of the term "plenum" as follows: "a structure for dispensing liquid."[307] I have considered and used this construction in my below analysis.

288. However, in my below summary analysis, I have applied MGT's interpretation of the claim term "dispense the dielectric fluid substantially uniformly upwardly through each appliance slot," as applied in its Final Infringement Contentions.

Best '463/Best '914

289. Best '463 and Best '914 disclose an inlet pipe (e.g. 440, 540, 640, 740) that, in my opinion, under MGT's interpretation of the claim scope, constitutes a plenum or "a structure for dispensing liquid." [308] Best '463 and Best '914 teach that "[t]he system may include at least one tank defining an interior volume and having a coolant inlet for receive a dielectric liquid coolant

[303] Best '463 at 15:9-12.
[304] Best Publication at [57], [0023], cls. 7, 16, 25.
[305] Best Decl. ¶ 8; *see also* Pl.'s Supp. Resp. to Defs.' Interrog. No. 13, Mar. 15, 2023 at 5; Boyd Dep. 219:11-18; 220:14-222:23, Dec. 7, 2023.
[306] Design - Green Revolution Cooling, RHOD0000899 at RHOD0000900; *see also* RHOD0000796 (showing circulation of fluid through the tank).
[307] Joint Stipulation on Claim Construction, ECF No. 50.
[308] *See, e.g.*, Best '463 at Figures 3-10.

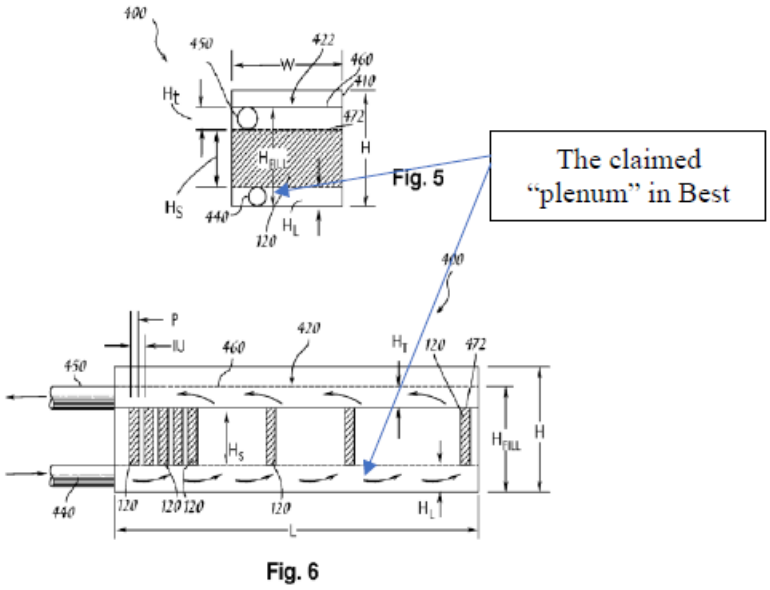
within the interior volume."[309] "The inlet piping 540 is located near one end of one of the longer sides of the rectangular tank near the bottom of the tank."[310]

290. Under MGT's interpretation of the claim scope as reflected in its Final Infringement Contentions, the inlet piping, by virtue of the placement at the bottom of the tank, creates substantially uniform pressure in the fluid layer below the electronic appliances and in turn would facilitate substantially uniformly upward flow, if the fluid layer or volume is sufficiently large. I also note that the Asserted Patents do not disclose or teach how to achieve a plenum adapted to dispense the dielectric fluid substantially uniformly upwardly, as discussed further in the Written Description and Enablement section below.

291. Best '463 and Best '914 describe that the mounting members within the tank "may also be configured to mount the servers in a server rack 470 above the bottom of the tank to create a volume of liquid coolant between each respective server and the bottom of the tank such that the flow of the dielectric liquid coolant through the servers is improved."[311] In its preferred embodiment, Best '463 and Best '914 identify that "the mounting members are configured to mount the servers closely adjacent to one another in the server rack to restrict flow of the dielectric liquid coolant between the vertically-oriented servers, such that the flow of the dielectric liquid coolant through the servers is enhanced."[312] Best '463 and Best '914 also describe the configuration of the tank to "permit the liquid coolant heated by the heat generating components in the servers to naturally rise through the servers and exit through the top or 'front panel' of the servers."[313] Thus, Best '463 and Best '914 each disclose that its plenum has been adapted to dispense the dielectric fluid substantially uniformly upwardly through each appliance slot.

292. It is also my understanding that during the prosecution history, the examiner indicated that limitation 1.5 is taught by Best '463, citing to the "H_L" portion in Figures 5-6 below. [314] I understand that MGT did not traverse the examiner's rejection with respect to these conclusions or otherwise distinguish the plenum in the Asserted Claims from the plenum in Best '463.

[309] Best '463 at 4:36-37.
[310] *Id.* at 15:63-65.
[311] *Id.* at 14:65-15:3 (emphasis added).
[312] *Id.* at 15:3-8 (emphasis added).
[313] *Id.* at 15:17-20.
[314] '457 Patent Prosecution History at MIDAS0003497-99.



Figures 5-6 (annotated).

293. I also understand that MGT did not attempt to distinguish the plenum as recited in limitation 1.5 from the plenum disclosed in Best '463 in the IPR or PGR.[315]

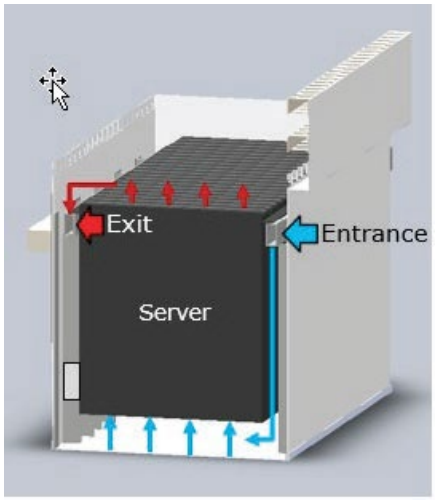
Best Publication/Best Tank

294. The Best Publication discloses "a structure for dispensing liquid." It teaches a pressure manifold, a structure for dispensing dielectric liquid coolant into the interior volume of a tank. The pressure manifold is fluidly coupled to a coolant inlet.[316] The Best Publication provides that "although the coolant inlet 612 and the coolant outlet 610 are on one side of the tank 600, the invention is not thus restricted. The coolant inlet 612 and the coolant outlet 610 may be located on any of the sides of the tank 600 as well as may each be located on a different side of the tank 600."[317] A POSA would understand that it could modify the pressure manifold of the Best Publication by positioning it at the bottom of the tank as a trivial design choice because doing so would be simple, straightforward, and would provide little additional benefit.

295. The pressure manifold has a plurality of flow augmentation devices for enhancing and directing the flow of the dielectric liquid coolant inside the interior volume.[318] The Best Publication explains that coolant flow is approximately equal along the length of the entire tank because the "area A_2 of the velocity augmentation devices along the length of the pressure manifold

[315] *See generally*, *Immersion Systems LLC v. Midas Green Technologies, LLC*, No. IPR2021-01176 (P.T.A.B. June 23, 2021); *Immersion Systems LLC v. Midas Green Technologies, LLC*, PGR2021-00104 (PTAB July 26, 2021).
[316] Best Publication at [57], [0023], cls. 8, 17, 26.
[317] *Id.* at [0068].
[318] *Id.* at [57], [0023].

is much smaller than the area A_1 of the pressure manifold."[319] As the dielectric liquid coolant comes out of the velocity augmentation devices along the length of the pressure manifold it goes around the outside of the computing systems, accelerates around the velocity augmentation devices, flowing downward and then flows upward through the computing systems in the



mounting slots.[320]

296. I understand that the manifold of the Best Tank is approximately as described in Figures 7A and 7B of the Best Publication.[321]

297. Furthermore, the chamber below the server and adjacent the bottom of the Best Tank is a plenum when it contains a volume of fluid. As illustrated above, the four arrows indicate a plenum dispensing fluid in a uniform upward flow toward the servers.[322]

298. I further understand that MGT has admitted that "the Best Tank contains a 'plenum' as recited in Claims 1, 6, and 11 of the '457 Patent" and "the Best Tank contains a 'plenum' as recited in Claims 1 and 6 of the '446 Patent."[323]

299. Therefore, it is my opinion that the pressure manifold described in the Best Publication and/or the chamber below the servers in the Best Tank satisfy limitation 1.5 of the '457 patent under MGT's interpretation of the claim scope as applied in its Final Infringement Contentions.

300. It is thus my opinion that the Best References each disclose or embody limitation 1.5 under MGT's interpretation of the claim scope as described in its Final Infringement Contentions.

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[319] *Id.* at [0070].
[320] *Id.* at [0071]-[0072].
[321] Best Decl. ¶ 9; *see also* Pl.'s Supp. Resp. to Defs.' Interrog. No. 13, Mar. 15, 2023 at 5; Boyd Dep. 219:11-18; 220:14-222:23, Dec. 7, 2023.
[322] TACC00000065 at 4; Boyd Dep. 203:19-23; 295:4-10, Dec. 7, 2023.
[323] Pl.'s Resp. to Defs.' Req. Admis. Nos. 18 & 19, Aug. 31, 2022.

Limitation 1.6: "a secondary fluid circulation facility adapted to extract heat from the dielectric fluid circulating in the primary circulation facility, and to dissipate to the environment the heat so extracted;"

301. It is my opinion that the Best References each teach or embody the elements recited in limitation 1.6.

Best '463/Best '914

302. Best '463 and Best '914 disclose "a secondary fluid circulation facility adapted to extract heat from the dielectric fluid circulating in the primary circulation facility, and to dissipate to the environment the heat so extracted" as recited in limitation 1.6.

303. The '457 patent identifies Best '463 as prior art that discloses secondary circulation facilities, by stating "[s]imilarly, practitioners in the art will readily recognize that other, known secondary circulation facilities may be employed effectively, including forced air, vapor compression systems, earth-water sink loops, waste heat recovery and recycling systems and the like (see, e.g., the several alternatives discussed in Best)."[324]

304. Best '463 and Best '914 disclose multiple embodiments which teach limitation 1.6. For example, "FIG. 1A illustrates one embodiment of an exemplary system for efficiently cooling a plurality of independently operable servers" and "FIG. 1B illustrates an alternative embodiment of an exemplary system for efficient cooling a plurality of independently operable servers."[325]

305. Additionally, Best '463 and Best '914 describe an alternate embodiment: "a secondary cooling system having a cooling fluid flowing in a second fluid circuit wherein the secondary cooling system rejects heat from the cooling fluid."[326]

306. During examination of the '457 patent, the examiner concluded that Best '463 teaches this limitation. I understand that MGT did not traverse the examiner's rejection with respect to this limitation.[327] I also understand that MGT did not argue that Best '463 does not disclose this limitation in either the IPR or PGR.

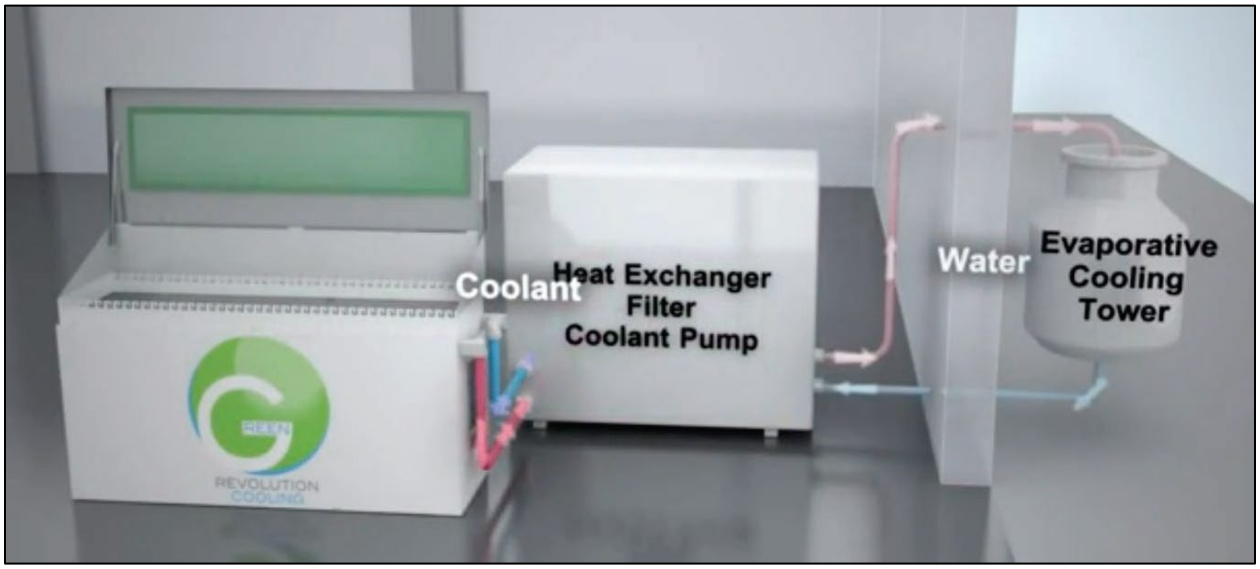
307. As such, it is my opinion that Best '463 and Best '914 each disclose limitation 1.6.

Best Publication/Best Tank

308. The Best Publication discloses "a secondary fluid circulation facility." It teaches a secondary cooling apparatus that rejects the heat from the dielectric liquid coolant in the tank and dissipates it.[328] The secondary cooling apparatus contains a second cooling fluid and forms a

[324] '457 patent at 9:14-20; '446 patent at 9:17-23 (emphasis added).
[325] Best '463 at 7:26-32.
[326] Best '463 at 5:9-11.
[327] '457 Patent Prosecution History at MIDAS0003497-500.
[328] Best Publication at [57], [0019], [0053]-[0054], [0060].

second fluid circuit.[329] Therefore, it is my opinion that the secondary cooling apparatus described in the Best Publication satisfies limitation 1.6 of the '457 patent.



309. I understand that that the Best Tank is an embodiment of the Best Publication.[330] Furthermore, the Best Tank is described as consisting of a pump module that draw heated coolant from the and expels the excess heat through a specified heat-exchange method, and of final heat exchanger that one of multiple options to reject heat from the coolant to the outside air.[331]

310. It is thus my opinion that the Best References each disclose or embody limitation 1.6.

Limitation 1.7: "a control facility adapted to coordinate the operation of the primary and secondary fluid circulation facilities as a function of the temperature of the dielectric fluid in the tank."

311. Under MGT's interpretation of the claim scope as reflected in its Final Infringement Contentions, it is my opinion that the Best References each teach or embody the elements recited in limitation 1.7.

312. I understand that MGT has not accused sensors that measure junction temperature as meeting any claim limitation (nor do such sensors meet any claim limitation).[332] In the Background

[329] *Id.* at [0060].
[330] Best Decl. ¶¶ 6-9.
[331] Design - Green Revolution Cooling, RHOD0000899 at RHOD0000901.
[332] *See generally, e.g.*, U.S. Patent No. 8,283,876B2; Bernie Siegal & Mark Berg, *An Effective Alternative for Marginal Thermal Improvements of Semiconductor Devices*, Tenth IEEE Semi Therm Synposium (1994); Thomas S. Tarter & Bernie Siegal, *Application of thermal test chips to stacked chip packages*, 29th IEEE Semiconductor Thermal Measurement and Management Symposium Year: 2013 13-22; Bernie Siegal, *Practical Considerations in High Power LED Junction Temperature Measurements*, 2006 Thirty-First IEEE/CPMT International Electronics Manufacturing Technology Symposium, Petaling Jaya, Malaysia, 62-66 (2006).

of Technology, I discussed general methods of measuring temperature, in particular the temperature of a liquid and the junction temperature of an electronic chip. I further pointed out that although the chip junction temperature is dependent on the liquid coolant temperature, they are distinct. In order to know the temperature of the fluid, directly, it is necessary to insert a temperature measuring device, e.g. a sensor such as that shown in Figure 16 directly into the fluid in the tank. A submerged insertion sensor of this type will be in intimate contact with the fluid and will reach thermal equilibrium with the fluid, *i.e.* it will reach the same temperature. Hence, it will measure the true fluid temperature. To the extent MGT does accuse such sensors of meeting any claim limitation, I reserve right to amend my opinions.

Best '463/Best '914

313. In my opinion, under MGT's interpretation of the claim scope, Best '463 discloses "a control facility adapted to coordinate the operation of the primary and secondary fluid circulation facilities as a function of temperature of the dielectric fluid in the tank" as recited in limitation 1.7.

314. Best '463 and Best '914 describe controlling the operation and flow of the fluid within the system via "a controller for monitoring the temperature of the dielectric liquid at least one location within the fluid circuit and for adjusting the flow of the dielectric liquid coolant."[333]

315. Furthermore, Best '463 and Best '914 disclose that "the system 100 includes a computer controller 180 of conventional design with suitable novel applications software for implementing the methods of the present invention" and that "the controller 180 may receive monitor signals of various operational parameters from various components of the cooling system 100 and the environment and may generate control signals to control various components of the cooling system" in order to "maintain the heated liquid coolant exiting the servers in the tank at a specific elevated temperature in order to sufficiently cool each of the servers."[334]

316. Best '463 and Best '914 state: "[t]he controller 270 may also monitor the temperature of the heat-generating electronic components in the servers in the server racks by electrically connecting the controller to the diagnostic output signals generated by conventional rack mountable servers. The controller may also monitor the flow and temperature of the cooling fluid 91 in the external fluid circuit 290."[335]

317. Additionally, Best '463 and Best '914 state: "the controller 180 may output signals to the heat rejection or cooling apparatus 250 to adjust the flow of the cooling liquid through the external fluid circuit and the amount of heat being rejected by the heat rejection or cooling apparatus 250 for sufficiently cooling each respective server while maintaining the heated liquid coolant exiting the servers at the elevated temperature to reduce the amount of energy consumed to sufficiently cool each of the servers."[336]

[333] Best '463 at 4:56-58.
[334] *Id.* at 10:44-54.
[335] *Id.* at 11:61-67.
[336] *Id.* at 12:1-9.

318. Figure 17A identifies by the dashed-lines, which depict information being passed from sensors in the primary and secondary circulation facilities and signals coming from the controller (see Figures 1A, 1B, 2 and 15 which identify dashed-lines), that the controller performs the functions controlling the operations of the primary and secondary circulation facilities and coordinating their operation. The dashed-lines indicate the controller performing the following functions: (a) "operationally enhancing fluid velocity of dielectric fluid through the servers;" (b) "monitoring the temperature of the dielectric liquid and server electronic components and flow rate of the dielectric liquid;" (c) "selecting the more efficient secondary cooling system to minimize energy;" and (d) "adjusting the fluid flow of the secondary cooling apparatus."[337]

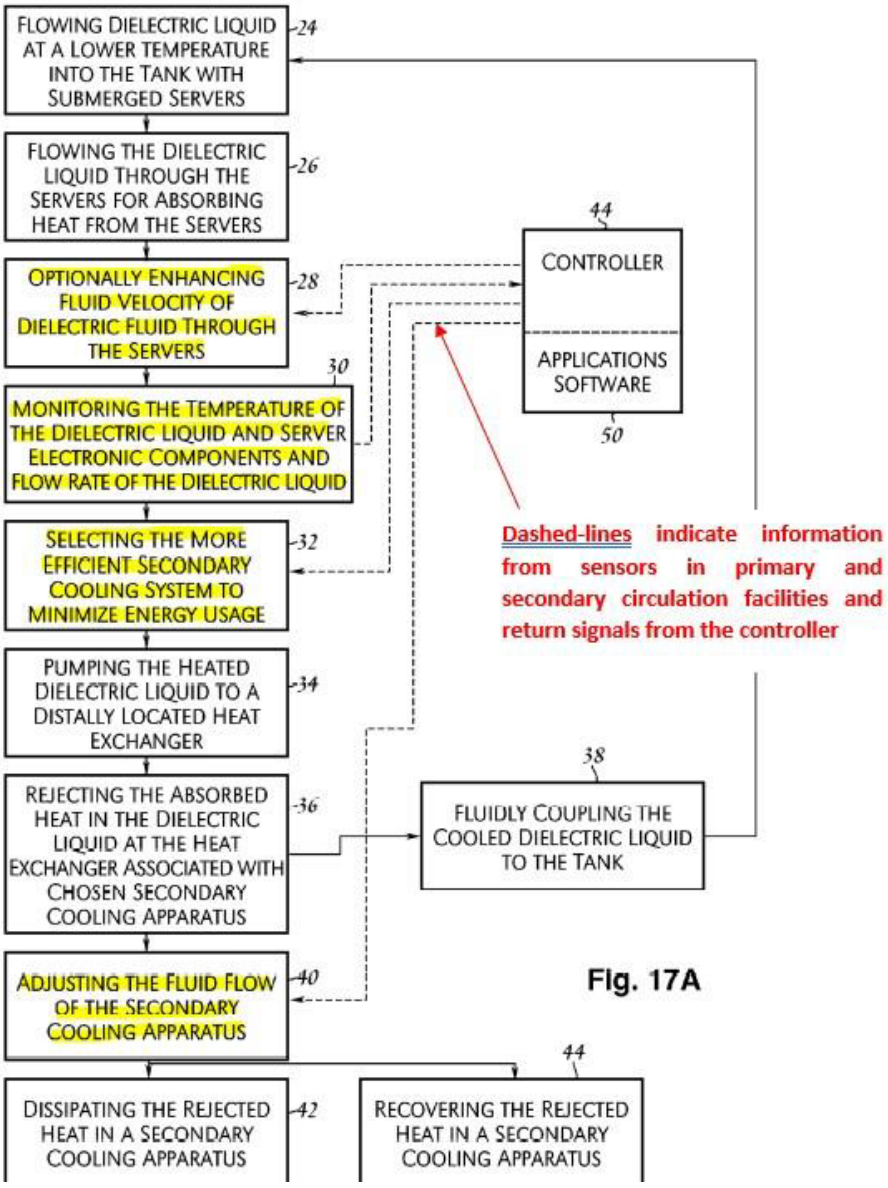


Figure 17A (annotated).

[337] *Id.* at Fig.17A.

319. The function of "optionally enhancing fluid velocity of dielectric fluid through the servers" relates to the dispensing of cool dielectric fluid within the tank, and therefore relates to the primary circulation facility. The function of "monitoring the temperature of the dielectric liquid and server electronic components and flow rate of the dielectric liquid" relates to flow of fluid throughout the tank, and therefore relates to the primary circulation facility. The function of "selecting the more efficient secondary cooling system to minimize energy usage" relates to cooling the warm dielectric fluid after passing through the tank, and therefore relates to the secondary circulation facility. The function of "adjusting the fluid flow of the secondary cooling apparatus" relates to flow of dielectric fluid as it passes through the cooling apparatus, and therefore relates to the secondary cooling facility.

320. During examination of the '457 patent, the examiner concluded that Best '463 teaches this limitation. I understand that MGT did not traverse the examiner's rejection with respect to this limitation. I also understand that MGT did not argue that Best '463 does not disclose this limitation in either the IPR or PGR.[338]

321. Therefore, it is my opinion that Best '463 and Best '914 each disclose limitation 1.7.

Best Publication/Best Tank

322. The Best Publication discloses "a control facility" in the form of a controller. Specifically, it teaches a controller to maintain the dielectric liquid at a specific temperature.[339] The controller monitors the temperature of the dielectric liquid at least at one location within the fluid circuit, and may also monitor the temperature of the heat generating electronic components in the computing systems. Based on this information, the controller outputs signals to adjust the flow through the primary fluid circuit of dielectric liquid as well as the amount of heat being rejected by the secondary cooling apparatus.[340]

323. I understand that that the Best Tank is an embodiment of the Best Publication.[341] Furthermore, the Best Tank is described as consisting of a control module. The control module manages coolant flow and heat-exchanger fan speed (of the secondary circulation facility or final heat exchanger) or pump speed (of the primary circulation facility or pump module) using a closed-loop temperature-control algorithm.[342]

324. Therefore, it is my opinion that the controller described in the Best Publication and Best Tank satisfy limitation 1.7 of the '457 patent.

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[338] *See* '457 Patent Prosecution History at MIDAS0003497-500, MIDAS0003483-3486; *see generally*, *Immersion Systems LLC v. Midas Green Technologies, LLC*, No. IPR2021-01176 (P.T.A.B. June 23, 2021); *Immersion Systems LLC v. Midas Green Technologies, LLC*, PGR2021-00104 (PTAB July 26, 2021).
[339] Best Publication at [0022].
[340] *Id.* at [0056], [0061]-[0063], cls. 5-6, 14-15, 23-224.
[341] Best Decl. ¶¶ 6-9.
[342] Design - Green Revolution Cooling, RHOD0000899 at RHOD0000901.

325. Accordingly, it is my opinion that the Best References each teach or embody the elements recited in limitation 1.7.

Comparison of Claims 1, 6, and 11

326. Claims 6 and 11 of the '457 patent repeat the limitations recited in claim 1, except with the following differences:

a. Claims 6 and 11 are directed to a "tank module" or "tank module (10)" adapted for use in an appliance immersion cooling system, rather than an appliance immersion cooling system. Claims 6 and 11 thus are directed to a subset of the elements recited in claim 1.
b. In particular, claim 11 omits the words "overflow lip" in limitation 1.3, instead reciting "a weir 22, integrated horizontally into the long wall of the tank (10) adjacent all appliance slots (18), adapted to facilitate substantially uniform recovery of the dielectric fluid flowing through each appliance slot (18)."
c. Claim 11 also does not recite limitation 1.4, "a dielectric fluid recovery reservoir positioned vertically beneath the overflow lip of the weir and adapted to receive the dielectric fluid as it flows over the weir."
d. Furthermore, claims 6 and 11 both omit limitation "secondary fluid circulation facility adapted to extract heat from the dielectric fluid circulating in the primary circulation facility, and to dissipate to the environment the heat so extracted" that is recited in limitation 1.6.
e. Claims 6 and 11 further rephrase the "control facility" limitation 1.7 to remove the "secondary fluid circulation facility" element. Specifically, claims 6 and 11 recite "a secondary fluid circulation facility adapted to control the operation of the primary fluid circulation facility as a function of temperature of the dielectric fluid in the tank" and "a control facility (58) adapted to control the operation of the primary fluid circulation facility (28) as a function of the temperature of the dielectric fluid in the tank (10)."[343]

Claim 6 and 11

327. It is my opinion that despite these differences, the Best References disclose all the limitations of claims 6 and 11. The below chart lists the limitations of claim 1 and the corresponding limitations of claims 6 and 11. My above summary of my analysis of the limitations of claim 1 apply equally to the corresponding limitations of claims 6 and 11, and I incorporate by reference that analysis herein for claims 6 and 11. My full analysis is presented in the claim charts attached hereto as **Exhibits D-1** through **D-9**.

Claim 1 Limitations	***Claim 6 Limitations***	***Claim 11 Limitations***
1.P	***6.P***	***11.P***
1.1	***6.1***	***11.1***
1.2	***6.2***	***11.2***
1.3	***6.3***	***N/A***

[343] *Compare* '457 patent at cl. 1 *with id.* at cls. 6, 11.

1.4	***6.4***	***11.3***
1.5	***6.5***	***11.4***
1.6	***N/A***	***N/A***
1.7	***6.6***	***11.5***

Limitation 6.P/Limitation 11.P: "A tank module adapted for use in an appliance immersion cooling system, the tank module comprising:"/A tank module (10) adapted for use in an appliance immersion cooling system, the tank module comprising:

328. To the extent, the preamble is limiting, a POSA would understand that the phrases "tank module adapted for use in an appliance immersion cooling system" and "tank module (10) adapted for use in an appliance immersion cooling system" have no unique meaning that would differentiate it from the preamble in claim 1. It is thus my opinion that even if the preamble of claims 6 and 11 were to be limiting, it would be found in the same disclosures identified as meeting the elements of limitation 1.P. of claim 1.

Limitation 6.6/Limitation 11.6: "a control facility adapted to control the operation of the primary fluid circulation facility as a function of the temperature of the dielectric fluid in the tank."/ "a control facility (58) adapted to control the operation of the primary fluid circulation facility (28) as a function of the temperature of the dielectric fluid in the tank (10)."

329. A POSA would understand that the language of claim 1 encompasses the language of claims 6 and 11. Limitations 6.6 and 11.5 require a control facility that controls the operation only of a primary fluid circulation facility as a function of the temperature. The control facility of limitation 1.7 also coordinates the operation of the primary fluid circulation facility, in addition to coordinating the operation of a secondary fluid circulation facility as a function of the temperature. The control facility of claim 1 thus recites the elements of the control facility of claims 6 and 11. In addition, a POSA would understand that "coordinate" to be synonymous with "control" in the context of the language of the claims of the '457 patent, and thus the same analysis with respect to the control facility of limitation 1.7 would also apply to the control facility of limitations 6.6 and 11.5.

330. Because there are no additional limitations to claims 6 and 11 that were not already discussed in claim 1, for at least the above reasons, it is my opinion that a POSA at the relevant time would have understood the limitations of claims 6 and 11 to be disclosed, taught, or suggested by each of the Best References.

<u>*Dependent Claims*</u>

Claim 2/Claim 7: "The system of claim 1 wherein the tank and primary circulation facility comprise a highly-integrated module."/ The module of claim 6 wherein the tank and primary circulation facility comprise a highly-integrated module."

331. In my opinion, the Best References each disclose that "the tank and primary circulation facility comprise a highly-integrated module" as recited in claims 2 and 7.

332. I incorporate by reference my above analysis with respect to claim 1 herein.

333. Furthermore, as discussed above for limitations 1.1, 1.4, and 1.5, each of the Best References discloses a tank and a primary circulation facility. Thus, for the reasons discussed for limitations 1.1, 1.4, and 1.5, the Best References each satisfy the limitations of claims 2 and 7.

Claim 5/Claim 10/Claim 14: "The system of claim 1 wherein the control facility further comprises a communication facility adapted to facilitate monitoring and control of the control facility from a remote location."/ "The module of claim 6 wherein the control facility further comprises a communication facility adapted to facilitate monitoring and control of the control facility from a remote location."/"The module of claim 11 wherein the control facility further comprises a communication facility (62, 64) adapted to facilitate monitoring and control of the control facility from a remote location."

334. In my opinion, the Best References each disclose "[t]he system of claim 1 wherein the control facility further comprises a communication facility adapted to facilitate monitoring and control of the control facility from a remote location," as recited in claims 5, 10, and 14.

I incorporate by reference my above analysis with respect to claim 1 herein.

Best '463/Best '914

335. In addition to the above analysis, Best '463 and Best '914 disclose that "the system 100 includes a computer controller 180 of conventional design with suitable novel applications software for implementing the methods of the present invention" and that "the controller 180 may receive monitor signals of various operational parameters from various components of the cooling system 100 and the environment and may generate control signals to control various components of the cooling system."[344]

336. Furthermore, Best '463 and Best '914 state: "[t]he controller 270 may also monitor the temperature 94 of the heat-generating electronic components in the servers in the server racks by electrically connecting the controller to the diagnostic output signals generated by conventional rack mountable servers. The controller may also monitor the flow and temperature of the cooling fluid in the external fluid circuit 290."[345]

337. The monitoring and controlling functions and associated structures in Best '463 and Best '914 are depicted in Figure 17A, indicated for example by items 30, 32, 40, and 44.

[344] Best '463 at 10:44-54 (emphasis added).
[345] *Id.* at 11:61-67 (emphasis added).

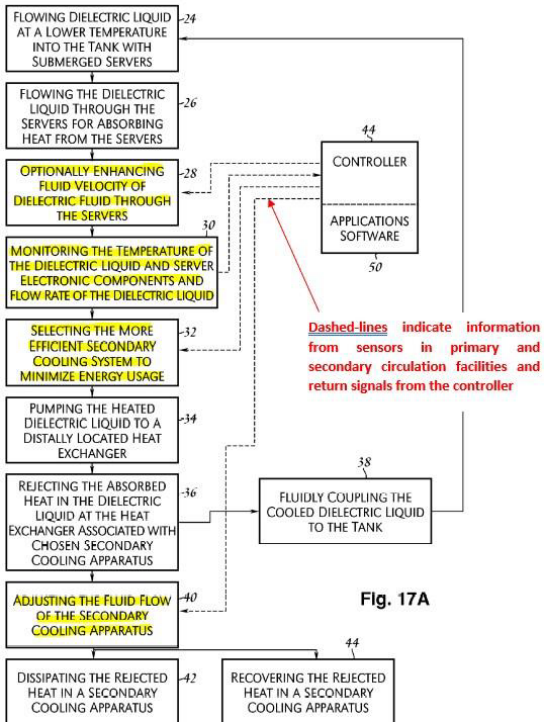

Figure 17A (annotated).

338. Best '463 and Best '914 disclose a communication facility for monitoring in describing that "the controller 180 may receive monitor signals of various operational parameters from various components of the cooling system 100 and the environment and may generate control signals to control various components of the cooling system"[346]

339. Best '463 and Best '914 likewise contemplate being able to remotely communicate with the control the system as "fluid valve 390 may be remotely controlled to connect the heated liquid 95 coolant being pumped through the collection piping from tank 310 to a controller-selected one of alternative remotely or distally located heat exchangers."[347]

340. It is my opinion that Best '463 and Best '914 disclose that the controller was adapted to communicate with the cooling system in Best '463, thereby controlling it from a remote location.

341. The controller of Best '463 and Best '914 could be placed in any location thus comprising a communication facility adapted to facilitate monitoring and control of the control facility from a remote location. The Asserted Patents identify that the communication facility may use "a conventional data communication hardware module 64, e.g., an ethernet card implementing the TCP/IP protocol, a modern web browser can be adapted to provide a graphical user interface ("GUI") with sufficient functionality to facilitate monitoring and control of an entire installation

[346] *Id.* at 10:44-54.
[347] *Id.* at 13:25-29 (emphasis added).

from a remote location. Such a GUI may be implemented using any of a number of programming paradigms, e.g., PHP, .NET and the like."[348]

342. The use of ethernet cards to communicate with the controller of immersion systems as well as the creation of a graphical user interface to assist in monitoring and communicating control signals to the immersion system was well known within the art of cooling electronic appliances, including immersion cooling, such as presented in Best '463 and Best '914. This technology is remote control, as used in claim 5.

343. Best '463 and Best '914 state that Figure 13 "may have cable trays 840 mounted along two sides of the tank 810 paralleling the sides of the server racks 830 and 832 to organize the signal and control network cabling 842 from the servers to the controller and other computers in the data center and beyond."[349] Figure 13 of Best '463 and Best '914 specifically identifies the use of ethernet or fiber connection for providing such communication capabilities.

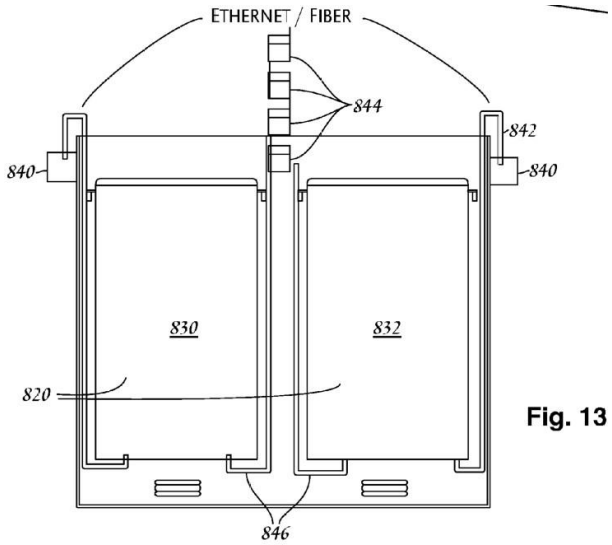

Fig. 13

Figure 13.

344. I understand that the examiner also agreed that Best '463 disclosed such a remote communication system, rejecting claim 5 in office actions consistently from November 4, 2016 until June 11, 2018, and that MGT did not traverse the examiner rejection with respect to this claim. [350] I also understand that MGT did not argue that Best '463 does not disclose this limitation in either the IPR or PGR.[351]

[348] '457 patent at 6:14-21; '446 Patent, 6:16-23.
[349] Best '463 at 18:52-57.
[350] *See, e.g.*, '457 Patent Prosecution History at MIDAS0003499-500.
[351] *See generally*, *Immersion Systems LLC v. Midas Green Technologies, LLC*, No. IPR2021-01176 (P.T.A.B. June 23, 2021); *Immersion Systems LLC v. Midas Green Technologies, LLC*, PGR2021-00104 (PTAB July 26, 2021).

345. Therefore, in my opinion, Best '463 and Best '914 disclose the limitations of claims 5, 10, and 14.

Best Publication/Best Tank

346. In addition to the above analysis with respect to limitation 1.7, the Best Publication discloses a controller that "receive[s] monitor signals of various operational parameters from various components of the cooling system 200 and the environment and may generate control signals to control various components of the cooling system 200 to maintain the heated liquid coolant exiting the servers in the tank at a specific elevated temperature," and "output[s] signals to the pump 212 and heat rejection or cooling apparatus 218 to adjust the flow of the liquid coolant through the fluid circuit and the amount of the heat being rejected by the heat rejection or cooling apparatus."[352]In my opinion, the signals disclosed in Best the Publication constitute a communication facility as recited in claims.

347. The Best Tank also discloses a control module described as being capable of smart monitoring and diagnostics. The control module also provides email and Simple Network Management Protocol ("SMNP") diagnostic alerts about the status and condition of the Best Tank.[353] In my opinion, these alerts and emails constitute and require a communication facility and allow for remote monitoring of the outputs of the control module.

348. According, in my opinion, the Best References each disclose the limitations of claims 5, 10, and 14.

Claim 15: "An appliance immersion cooling system comprising a tank module according to any one of the preceding claims 11 through 14."

349. In my opinion, the Best References each disclose an appliance immersion cooling system as recited in claim 15. Specifically, I incorporate by reference my above analysis with respect to claims 11 and 14 herein.

Opinions Regarding the '446 Patent

350. I have read and analyzed the '446 patent against the prior art. Based on my review of the prior art, and in light of the parties' Joint Stipulation on Claim Construction, it is my opinion that every limitation recited in the Asserted Claims of the '446 patent is included, either explicitly or inherently, in the Best References. My full analysis of these prior art references is presented in the claim charts attached hereto as **Exhibits E-1** through **E-9**. Below is a summary of the attached claim charts.

[352] Best Publication at [0056], [0061], [0063].
[353] Design - Green Revolution Cooling, RHOD0000899 at RHOD0000901.

Independent Claims

Claim 1

351. Claim 1 of the '446 patent replicates claim 1 of the '457 patent, except that it:

a. Omits the words "overflow lip" from limitation 1.2, reciting instead, "a weir, integrated horizontally into the long wall of the tank adjacent all appliance slots, adapted to facilitate substantially uniform recovery of the dielectric fluid flowing through each appliance slot."

b. Omits limitation 1.3, "a dielectric fluid recovery reservoir positioned vertically beneath the overflow lip of the weir and adapted to receive the dielectric fluid as it flows over the weir."

352. I therefore incorporate by reference that analysis from claim 1 of the '457 patent herein for claim 1 of the '446 patent. Because there are no additional limitations to claim 1 of the '446 patent that were not already discussed in claim 1 of the '457 patent, it is my opinion that for at least these reasons the limitations of claim 1 of the '446 patent are expressly disclosed by the each of the Best References.

Claim 6

353. Claims 6 of the '446 patent repeat the limitations recited in claim 1 of the '457 patent, except with the following differences:

a. Omits the words "overflow lip" from limitation 1.2, thus reciting, "a weir, integrated horizontally into the long wall of the tank adjacent all appliance slots, adapted to facilitate substantially uniform recovery of the dielectric fluid flowing through each appliance slot."

b. Omits limitation 1.3, "a dielectric fluid recovery reservoir positioned vertically beneath the overflow lip of the weir and adapted to receive the dielectric fluid as it flows over the weir."

c. Omits limitation 1.6, "a secondary fluid circulation facility adapted to extract heat from the dielectric fluid circulating in the primary circulation facility, and to dissipate to the environment the heat so extracted."

354. My analysis of claim of the '457 patent thus applies equally to the limitations of claim 6 of the '446 patent. Because the phrase "tank module adapted for use in an appliance immersion cooling system" has no unique meaning that would differentiate it from the preamble in claim 1 of the '446 patent, even if the preamble of this claim were to be limiting, it would be found in the same features identified in the Best References with respect to an "appliance immersion cooling system" found in claim 1 of the '457 and '446 patents.

355. Additionally, because "coordinate" is synonymous with "control" in the context of the language of the claims of the '446 patent, the same analysis with respect to the control facility (i.e. limitation 1.7) would also apply here to disclose the limitation in this claim. Even if the language were not synonymous, limitation 1.7 discloses that the primary circulation facility and the temperature of the fluid therein is controlled by the control facility.

356. Because there are no additional limitations to claim 6 of the '446 patent that were not already discussed in claim 1 of the '457 patent, it is my opinion that for at least these reasons the limitations of claim 6 of the '446 patent are disclosed by each of the Best References.

Dependent Claims

Claim 2/Claim 7: "The system of claim 1 wherein the tank and primary circulation facility comprise a tightly co-located module."/"The module of claim 6 wherein the tank and primary circulation facility comprise a tightly co-located module."

357. Claims 2 and 7 of the '446 patent replicate claims 2 and 7 of the '457 patent, respectively. My analysis of these claims with respect to the '457 patent applies equally to the respective claims of the '446 patent, and I incorporate it by reference here. It is thus my opinion that the Best References each teach the elements of the asserted dependent claims of the '446 patent.

Claim 5/Claim 10: "The system of claim 1 wherein the control facility further comprises a communication facility adapted to facilitate monitoring and control of the control facility from a remote location."/"The module of claim 6 wherein the control facility further comprises a communication facility adapted to facilitate monitoring and control of the control facility from a remote location."

358. Claims 5 and 10 of the '446 patent replicate claims 5 and 10 of the '457 patent, respectively. My analysis of these claims with respect to the '457 patent applies equally to the respective claims of the '446 patent, and I incorporate it by reference here. It is thus my opinion that the Best References disclose each element of claims 5 and 10 of the '446 patent.

OBVIOUSNESS

Motivation to Combine

359. In my opinion, it would have been obvious to a POSA to combine the teachings of two or more of Best '463, the Best Publication, the Best Tank, Oktay '244, JP '758, the Pfahnl Publication, Krajewski '511, Gryzhin '013, Best '914, Rolfson '298, Attlesey '419, and Quon '108.

360. First, the references are analogous art, generally directed to liquid cooling systems for electronic computing components. The Asserted Patents identify Krajewski '511, Cray' 538, and Best '463 as electronic computing components cooling systems, and more specifically, as immersion cooling systems for cooling electronic components during normal operation. Krajewski '511 discloses "stacked CP boards surrounded on two sides by CMM boards stacked in perpendicular planes [] submerged in a thermally conductive, electrically insulated bath to provide sufficient cooling of the boards during operation." Cray' 538, which Krajewski '511 incorporates by reference,[354] describes "[a]n immersion cooling system for high density electronic assemblies such as computers includ[ing] a container holding an inlet cooling liquid, and stacks of circuit modules arranged in a generally radial pattern within the container." The Best References are

[354] To the extent that the incorporation by reference into Krajewski '511 of Cray '538 does not render them available as a single reference, then the explicit reference by Krajewski '511 to Cray '538 would offer a clear and express suggestion to combine the references to a POSA.

similarly directed to or embody apparatus, systems, and methods for cooling computing components immersed or submerged in a dielectric liquid coolant.

361. Oktay '244, Gryzhin '013, and Attlesey '419 are also each directed to liquid submersion or immersion cooling systems.[355] Rolfson '298, JP '758, and Quon '108 disclose immersion cooling systems for specific applications. Rolfson '298 teaches a liquid bath apparatus for use in semiconductor fabrication, wherein a surface of a substrate that ultimately forms electrical devices and paths is exposed to a circulating liquid bath.[356] JP '758 teaches an apparatus for cooling an electronic circuit component, such as a semiconductor device, immersed in a liquid coolant and performing a bias test.[357] Quon '108 is directed to a system for cooling an electronic semiconductor power module consisting of a dielectric liquid coolant flowing over the module.[358] The Pfahnl Application teaches a system for air cooling orthogonally oriented arrays of parallel circuit boards. While it does not teach a liquid immersion cooling system specifically, it acknowledges that prior art liquid cooling systems may be used in conjunction with air cooling systems.[359] Furthermore it teaches the use of inflow and outflow plenums in the flow management system.

362. Second, the combinations of the references represent the selection of known techniques to known devices to arrive at a predictable solution. In particular, the combinations of the references solve the problems identified in the Asserted Patents. The Asserted Patents identify the following problems with the prior art: (1) use of vertical-stack-type system; (2) conserving floor space; (3) non-uniform flow patterns; (4) constricted dielectric fluid supply and return ports; (5) poor scalability; and (6) inadequate attention to fail-soft operation.[360]

363. The Asserted Patents acknowledge that solutions to the identified problems already existed in the prior art. For example, the Asserted Patents state that a solution to the problem associated with the use of vertical-stack-type systems is to "immerse circuit assemblies vertically into a tank containing the cooling fluid such that each of the various assemblies can be withdrawn independently from the tank for servicing, replacement, upgrade, etc."[361] The Asserted Patents identify Puget as disclosing an example of this solution, but under MGT's interpretation of the claim scope as described in its Final Infringement Contentions, the Best References, Okay '244, Gryzhin '013, Quon '108, and JP '758 each disclose immersing electronic computing appliances vertically into dielectric coolant. The vertical servers are shown, for example, in Figures 10 through 14 of Best '463 and Best '914, Figures 3 and 6 of the Best Publication, Figure 1 of Okay '244,[362] Figure 1 of JP '758,[363] Figure 1 of Quon '108,[364] Figures 3A, 8A, and 9 of

[355] *See, e.g.*, Oktay '244 at 1:10-24, Fig. 2; Gryzhin '013 at 8:3-5, Figs. 1, 2; Attlesey '419 at [57], Figs. 13A and 13B.
[356] *See, e.g.*, Rolfson '298 at 3:50-62, Fig. 1.
[357] *See, e.g.*, JP '758 at [0001], [0008], Fig. 1.
[358] *See, e.g.*, Quon '108 at cl. 1, [57], 1:6-12, Fig. 1.
[359] Pfahnl Application at [57], [0010]-[0011].
[360] *Id.* at 2:23-37.
[361] '457 patent at 2:3-6; '446 patent at 5-9.
[362] Okay '244 at Fig. 1 (31).
[363] JP '758 at Fig. 1 (10).
[364] Quon '538 at Fig. 1 (30), 1:60-64 ("It is another purpose and advantage of this invention to position the die and its substrate in a vertical orientation.")

Attlesey '419,[365] and in the Best Tank.[366] The combination of one or more of the Best References, Quon '108, Oktay '244, and JP '758 with one or more of Pfahnl Publication, Gryzhin '013, Rolfson '298, and Krajewski '511, incorporating Cray '538, to achieve the claimed invention of the Asserted Patents represents applying known techniques to known devices to arrive at a predictable solution. A POSA would have been capable of applying the use of vertical servers to these references to yield results predictable to a POSA.

364. The Asserted Patents identify "floor space" as being a concern dictating a "modular configuration."[367] The Asserted Patents identify placing a fluid recovery reservoir directly beneath a weir as a solution.[368] Under MGT's interpretation of the claim scope as described in its Final Infringement Contentions, the Best References, Oktay '244, JP '758, Krajewski '511, and Rolfson '298 each discloses a fluid recovery reservoir directly beneath a weir. As discussed above, the Best References each disclose a fluid recovery reservoir directly beneath a weir.[369] Oktay '244, JP '758, Krajewski '511, and Rolfson '298 also implements designs with a reservoir beneath a weir or overflow orifice. This design is depicted in, for example, Figure 1 of Krajewski '511 and Figures 2, 3, 12, and 14 of Cray '538, Figure 1 of JP '758, and Figures 1 and 5 of Rolfson '298. In addition, Oktay '244 implemented a design exploiting gravity and a vertically arranged reservoir to maintain a compact footprint. As Oktay '244 states, "[a] pool of liquid 93 collects, above the bottom wall of enclosure 85. This pool 93 is maintained level by a suitably-controlled pump 97 which draws the liquid through heat exchanger 99."[370] The combination of one or more of Best '463, Best '914, the Best Publication, the Best Tank, Oktay '244, JP '758, Krajewski '511, and Rolfson '298 with one or more of the Pfahnl Publication, Gryzhin '013, Attlesey '419, and Quon '108 represents applying known techniques to known devices to arrive at a predictable solution. A POSA would have been capable of applying the use of a fluid recovery reservoir directly beneath a weir to these references to yield results predictable to a POSA.

365. The Asserted Patents identify Best '463 as suffering from non-uniform flow patterns; constricted dielectric fluid supply and return ports; poor scalability; and inadequate attention to fail-soft operation.[371] The solutions offered by the Asserted Patents had already been identified in the art for application to immersion cooling. For example, Oktay '244, Gryzhin '013, Rolfson '298, and JP '758 describe an overflow weir. And "dribbling down" the walls as described in Oktay '244 and taught in Gryzhin '013, Rolfson '298, and JP '758 would assure a POSA that no excessive velocity issues were encountered.

366. The "system-wide redundancy" discussed by the Asserted Patents appears to be a reference to little more than common concepts of design redundancy, which, in any event, are not claimed.

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[365] Attlesey '419 at Figs. 3A, 8A , 9 (30).
[366] Design - Green Revolution Cooling at RHOD0000899 (describing a rack system that accepts servers vertically rather than horizontally.
[367] '457 patent at 8:65-66; '446 patent at 9:1-3.
[368] '457 patent at 4:27-36; '446 patent at 4:29-38.
[369] Best '463 at 4:45-46; 18:23-29; Best Publication at Figs. 6, 7A, [0069]-[0070].
[370] Oktay '511 at 3:50-57 (emphasis added).
[371] '457 patent at 3:32-33; '446 patent at 3:35-37.

367. The Asserted Patents appears to draw its claim for modular scalability from the vertical weir/reservoir arrangement. This weir/reservoir arrangement was well-known. In fact, this achievement is in fact a significant innovation of the Cray-2 design, which the Asserted Patents points out corresponds to Cray '538.[372] The inclusion of a reservoir is a common and obvious choice in systems, including the immersion cooling systems disclosed in Best Tank, Best Publication, Oktay '244, Gryzhin '013, Rolfson '298, and JP '758, and provides the benefit of both a reserve of fluid (as is the nature of a reservoir) and maintaining sufficient head pressure to enable pumping of the fluid to a heat exchanger or back through the apparatus. The placement of a reservoir vertically below a weir is an obvious exploitation of gravity, which permits collection of fluid at the base of the weir without substantial additional configuration.

368. The existence of a rationale to combine references (with respect to all grounds presented) is supported by the file history in this case. The examiner identified Best '463 in combination with other immersion cooling apparatuses in the November 4, 2016 and May 17, 2017 rejections (Best '463 in combination with Pfahnl Application), and the June 11, 2018 rejection (Best '463 with JP '100). In the applicant's January 31, 2017 and August 24, 2017 responses, and the notes of any interviews, to my knowledge, the applicant never argued that a POSA would not combine any of Best '463, Pfahnl Application, or JP '100. The Best Publication, the Best Tank, Oktay '244, JP '758, Krajewski '511, Gryzhin '013, Best '914, Rolfson '298, Attlesey '419, and Quon '108 are analogous art to Best '463.

369. Third, a POSA would have a strong expectation of success in the identified combinations, which would be obvious to try. To the extent, the Best '463 does not implement the weir/reservoir and/or plenum arrangement as claimed in the Asserted Patents, this is simply an issue of design consideration. The prior art demonstrates that when such a design consideration is present, the weir/reservoir arrangement solution offered by the Best Publication, the Best Tank, Oktay '244, JP '758, Krajewski '511, and Rolfson '298 would have been an obvious option for a POSA to try with a reasonable expectation of success. Likewise, the plenum arrangement solution offered by the Best Publication, the Best Tank, Krajewski '511, Gryzhin '013, Rolfson '298, Quon '108, and Attlesey '419 would have been an obvious option for a POSA to try with a reasonable expectation of success.

370. Furthermore, the abundance of other skilled artisans arriving at the very same weir and reservoir and/or plenum arrangement as the Asserted Patents, including the Best Publication, the Best Tank, Oktay '244, JP '758, the Pfahnl Publication, Krajewski '511, Gryzhin '013,[373] Rolfson '298, Attlesey '419, and Quon '108, demonstrate that a POSA would find such a design approach obvious.

371. At least for the above reasons, a POSA have been motivated to combine two or more of Best '463, the Best Publication, the Best Tank, Oktay '244, JP '758, the Pfahnl Publication, Krajewski '511, Gryzhin '013, Best '914, Rolfson '298, Attlesey '419, and Quon '108. For

[372] Cray '538 at 1:33-53.

[373] To the extent Gryzhin '013 is not prior art, it exemplifies the capability of other artisans. Gryzhin '013 demonstrates use of a modular configuration using vertically slotted electrical appliances immersed in dielectric fluid, flowing over a weir and into a reservoir vertically beneath was known in the art, reinforcing that such a design approach would be obvious.

example, it would have been obvious to a POSA to combine Best '463 or the Best Publication with JP '758 or Oktay '244 and Quon '108 because the references are analogous art; the combination of the references represent the selection of known techniques to known devices to arrive at a predictable solution; and the combination of the references would be obvious to try with a reasonable expectation of success.

372. In addition, in view of the state of the art at the time, a POSA would have had a reasonable expectation of success in modifying Best '463, Best Publication, Best Tank, Krajewski '511, Oktay '244, Gryzhin '013, Oktay '244, JP '758, Pfahnl Application, or Best '914 with the teachings of one or more of Best '463, the Best Publication, the Best Tank, Krajewski '511, Oktay '244, Gryzhin '013, Oktay '244, JP '758, the Pfahnl Application, Best '914, Rolfson '298, Attlesey '419, or Quon '108 for the following reasons.

373. A POSA would have been motivated to combine the teachings of these references given that the use of liquid cooling versus air cooling is known to better cool electronic computing components, and would lead to more efficient and effective cooling. This would be seen as a benefit to a POSA working within the framework of Best '463, the Best Publication, the Best Tank, Krajewski '511, Oktay '244, Gryzhin '013, Oktay '244, JP '758, the Pfahnl Application, or Best '914.

374. A POSA would have been motivated to combine the teachings of Krajewski '511 or the Pfahnl Application with the teachings of one or more of Best '463, the Best Publication, the Best Tank, Gryzhin '013, Oktay '244, JP '758, or Best '914 because placing all the immersed electronic computing devices in the same orientation (e.g. transverse to the long wall of the tank), would lead to more consistent, and more effective, cooling. This would be seen as a benefit to a POSA in view of the teachings of Krajewski '511 or the Pfahnl Application.

375. A POSA would have been motivated to combine the teachings of Best '463, Best Publication, Best Tank, Krajewski '511, Gryzhin '013, Oktay '244, JP '758, Pfahnl Application, or Best '914 with the teachings of one or more of Best '463, the Best Publication, the Best Tank, Krajewski '511, Gryzhin, JP '758, or Best '914 because allowing for multiple appliance slots would increase the number of appliances that can be cooled in one tank, thereby decreasing the number of tanks required to cool a plurality of appliances. This would be seen as a benefit to a POSA working within the framework of Best '463, the Best Publication, the Best Tank, Krajewski '511, Gryzhin '013, Oktay '244, JP '758, the Pfahnl Application, or Best '914.

376. A POSA would have been motivated to combine the teachings of Best '463, the Best Publication, the Best Tank, Krajewski '511, Gryzhin '013, Oktay '244, JP '758, the Pfahnl Application, or Best '914 with the teachings of one or more of Best '463, the Best Publication, the Best Tank, Gryzhin '013, Oktay '244, JP '758, the Pfahnl Application, Best '914, or Rolfson '298 because the use of a weir, or overflow lip, adapted to facilitate substantially uniform flow of air, or dielectric fluid, would increase efficiency in the overall flow of air, or dielectric fluid in the tank, thereby promoting more efficient cooling and higher processing speeds. This would be seen as a benefit to a POSA in view of the teachings of Best '463, the Best Publication, the Best Tank, Krajewski '511, Gryzhin '013, Oktay '244, JP '758, the Pfahnl Application, or Best '914.

377. A POSA would have been motivated to combine the teachings of Best '463, Best Publication, Best Tank, Krajewski '511, Gryzhin '013, Oktay '244, JP '758, Pfahnl Application, or Best '914 with the teachings of Attlesey '419 because the use of a hot liquid coolant outlet positioned at the top of the tank for passage into a heat exchanger, adapted to facilitate substantially uniform flow, and recovery, of dielectric fluid would increase efficiency in the overall flow of dielectric fluid in the tank, thereby promoting more efficient cooling and higher processing speeds. This would be seen as a benefit to a POSA in view of the teachings of Best '463, the Best Publication, the Best Tank, Krajewski '511, Gryzhin '013, Oktay '244, JP '758, the Pfahnl Application, or Best '914.

378. A POSA would have been motivated to combine the teachings of Best '463, the Best Publication, the Best Tank, Krajewski '511, Gryzhin '013, Oktay '244, JP '758, the Pfahnl Application, or Best '914 with the teachings of Best '463, the Best Publication, the Best Tank, Krajewski '511, Gryzhin '013, Oktay '244, JP '758, or Best '914 because a separate heated coolant recovery reservoir and recirculation of liquid coolant outside of the primary cooling circuit would ensure that the dielectric fluid passing through the electronic computing components would stay sufficiently cool, and therefore promote more efficient and effective cooling and higher processing speeds of the electronic computer components. Such a modification would also improve the flow of the dielectric fluid evenly through the plurality of electronic components, allowing for consistent cooling throughout the tank. This would be seen as a benefit to a POSA in view of the teachings of Best '463, the Best Publication, the Best Tank, Krajewski '511, Gryzhin '013, Oktay '244, JP '758, the Pfahnl Application, or Best '914.

379. A POSA would have been motivated to combine the teachings of Best '463, the Best Publication, the Best Tank, Krajewski '511, Gryzhin '013, Oktay '244, JP '758, the Pfahnl Application, or Best '914 with the teachings of one or more of Best '463, the Best Publication, the Best Tank, Krajewski '511, the Pfahnl Application, Gryzhin '013, Best '914, Rolfson '298, Attlesey '419, or Quon '108 because the use of fans or a plenum to circulate air or dielectric fluid would serve to increase the flow of the cooling material such that it would overflow the tank and cool the electronic devices therein. In addition, such a modification would increase the mixing of the dielectric liquid coolant within the tank and improve the flow of the fluid through the plurality of electronic components. This would have been seen as a benefit to a POSA working within the framework of Best '463, the Best Publication, the Best Tank, Krajewski '511, Gryzhin '013, Oktay '244, JP '758, the Pfahnl Application, or Best '914.

380. A POSA would have been motivated to combine the teachings of Best '463, the Best Publication, the Best Tank, Krajewski '511, Gryzhin '013, Oktay '244, JP '758, the Pfahnl Application, or Best '914 with the teachings of one or more of Best '463, the Best Publication, the Best Tank, Krajewski '511, Cray '538, Gryzhin '013, Oktay '244, JP '758, Pfahnl Application, or Best '914 because the use of liquid cooling versus air cooling, as well as a secondary circulation facility would ensure more efficient and effective cooling in the tank through the primary fluid circulation circuit which, in turn, would improve processing speeds. This would have been seen as a benefit to a POSA working within the framework of Best '463, the Best Publication, the Best Tank, Krajewski '511, Gryzhin '013, Oktay '244, JP '758, the Pfahnl Application, or Best '914.

381. A POSA would have been motivated to combine the teachings of Best '463, the Best Publication, the Best Tank, Krajewski '511, Oktay '244, Gryzhin '013, Oktay '244, the Pfahnl

Application, or Best '914 with the teachings of one or more of Best '463, the Best Publication, the Best Tank, Oktay '244, JP '758, or Best '914 because the use of a control system would reduce the amount of energy consumed to sufficiently cool the computing systems and provide for more effective cooling, which, in turn, would improve processing speeds. For example, Best '463 demonstrates the benefits of using such a system, including so that the temperature in the tank can be monitored and controlled. Given that the stated purpose of JP '758 was to "increase the reliability of bias temperature tests,"[374] in part by installing an insulation sensor for detecting an insulation resistance of a cooling liquid,[375] a POSA would be motivated to create even more control over the system. Furthermore, a controller is standard equipment that would fit into the system already provided in Best '463, the Best Publication, the Best Tank, Krajewski '511, Oktay '244, Gryzhin '013, Oktay '244, JP '758, the Pfahnl Application, or Best '914 with no more than routine modifications. This would be seen as a benefit to a POSA working within the framework of the Best '463, the Best Publication, Best Tank, Krajewski '511, Oktay '244, Gryzhin '013, Oktay '244, the Pfahnl Application, or Best '914.

382. A POSA would have been motivated to combine the teachings of Best '463, the Best Publication, the Best Tank, Krajewski '511, Oktay '244, Gryzhin '013, Oktay '244, JP '758, the Pfahnl Application, or Best '914 with the teachings of one or more of Best '463, the Best Publication, the Best Tank, Oktay '244, or Best '914 because the use of liquid cooling over air cooling, as well as a control facility operable from a remote location would reduce the amount of energy consumed to sufficiently cool the computing systems and provide for more effective cooling, which, in turn, would improve processing speeds. This would be seen as a benefit to a POSA in view of the teachings of Best '463, the Best Publication, the Best Tank, Krajewski '511, Oktay '244, Gryzhin '013, Oktay '244, JP '758, the Pfahnl Application, or Best '914.

383. Therefore, in my opinion, it would have been obvious to a POSA to combine the teachings of two or more of Best '463, the Best Publication, the Best Tank, Oktay '244, JP '758, the Pfahnl Publication, Krajewski '511, Gryzhin '013, Best '914, Rolfson '298, Attlesey '419, and Quon '108.

Secondary Consideration

384. I understand that in response to Rhodium's Interrogatory No. 14 ("Interrogatory No. 14"), MGT has asserted certain secondary considerations of nonobviousness. I have considered MGT's purported secondary considerations of non-obviousness, and it is my opinion that they do not refute my above analysis on obviousness. I do not see any technical merit to MGT's purported secondary considerations that in my opinion establishes that the Asserted Patents' purported invention was nonobvious.

Copying by Others

385. MGT has stated that copying by others of the purported invention is evidence of non-obviousness. MGT's response relating to its assertion of copying by others states:

[374] JP '758 at [0011].
[375] *Id.* at [0005].

> Copying by Rhodium (whether directly or indirectly), Immersion Systems, GRC, Argo Blockchain, and by Engineered Fluids of MGT's patented technology is evidence of a secondary consideration of non-obviousness. Industry players, including at least the Defendants, have copied MGT's patented technology because it offers significant benefits in the efficiency of their Bitcoin mining, leading to substantially increased revenue over non-infringing alternatives. MGT's inventions are now being used with increasing frequency throughout the cryptocurrency mining industry—both authorized and unauthorized—because of their substantial benefits.[376]

386. MGT also identifies as evidence of copying by others: (1) Rhodium's Rockdale, TX Bitcoin mining facility; (2) Rhodium's Temple, TX Bitcoin mining facility; (3) Rhodium's Godly, TX Bitcoin mining facility; (4) Engineered Fluids' immersion cooling products; (5) GRC's GEN 2 tank; and (6) Argo Blockchain's immersion cooling Bitcoin facility in West TX.[377]

387. In my opinion, there is no nexus between alleged copying by others with the alleged invention. While MGT has alleged there is copying by others of its purported invention, MGT has not provided any evidence to substantiate such claims. In other words, MGT presents no evidence that its competitors have actually copied MGT's claimed invention, as opposed to simply identifying that a mere similarity exists that are the result of independent development.

388. To the contrary, I am not aware of any evidence in this matter to suggest that Rhodium had knowledge of the Asserted Patents prior to development of the accused product, let alone that Rhodium copied the purported invention. Further, although MGT specifically alleges that two other entities, Engineered Fluids and GRC, have copied its purported invention, it does not provide any evidence or explanation as to how these entities have copied the purported invention.

389. Finally, MGT generally states, on information and belief, that Argo Blockchain copied the purported invention. MGT again it does not provide any evidence or explanation as to how Argo Blockchain has copied the purported invention.

390. Therefore, it is my opinion that MGT has not shown copying by others with the claimed invention.

Commercial Success

391. MGT has alleged that the failure of others prior to the purported invention is evidence of non-obviousness. MGT states the following:

> MGT's patented immersion cooling products have been a resounding commercial success, leading to significant interest and sales of MGT's product. This success is due to the substantial efficiency and operational improvements offered by the patented

[376] Pl.'s Supp. Resp. to Defs.' Interrog. No. 14 , Mar. 13, 2023 at 4.
[377] *See id.* at 4-6.

> technology, which offers the significant efficiency benefits of immersion cooling (as opposed to air-cooling), as well as the operational efficiency benefits of MGT's patented products (which by use of the recited plenum and weir results in the uniform flow and recovery of the cooling dielectric fluid through appliance slots, leading to uniform cooling and the absence of operationally obstructive "hot spots"). With respect to immersion cooling of servers and related appliances used in data centers, MGT's patented products are now recognized and approved for use with appliances of multiple manufacturers, including the following leading technology companies with whom Midas partners: Dell, Lenovo, Exuvi8, Edge Data Solutions, GPUnity, Modius, Alcatex, Inc., PCPC Direct, ITRenew, and others. With respect to immersion cooling of specialized computer appliances used for cryptocurrency mining, for example Bitcoin mining, MGT's more recently introduced patented immersion cooling products have been a near-instant success. Midas has received, fulfilled, and made proposals for a substantial number of high-volume orders placed for leading cryptocurrency mining companies, as well as an even greater number of lower-volume orders for smaller cryptocurrency mining companies.[378]

392. MGT asserts that the nexus between its purported commercial success and the claimed invention is "due to the substantial efficiency and operational improvements offered by the patented technology, which offers the significant efficiency benefits of immersion cooling (as opposed to air-cooling), as well as the operational efficiency benefits of Midas' patented products (which by use of the recited plenum and weir results in the uniform flow and recovery of the cooling dielectric fluid through appliance slots, leading to uniform cooling and the absence of operationally obstructive "hot spots")."[379]

393. I have not seen documentation that would support MGT's allegations of commercial success tied to the claimed invention. To the extent the Asserted Patents have achieved the commercial success that MGT alleges, I have seen no evidence that such commercial success is due to the claimed invention described in the Asserted Claims.

394. First, the alleged invention fails to adequately disclose the existence of a liquid layer of dielectric fluid above the appliance slots, a vital aspect to achieve uniform cooling. As a result, the purported invention would exhibit the "operationally obstructive 'hot spots'" that MGT claims to have solved.

[378] *Id.* at 6-7.
[379] *Id.*

395. Second, MGT asserts that its purported invention "offers the significant efficiency benefits of immersion cooling (as opposed to air-cooling)."[380] However, the efficiency benefits of immersion cooling versus air cooling had long been known in the art, as discussed above.[381]

396. Third, MGT asserts that the "operational efficiency benefits of Midas' patented products (which by use of the recited plenum and weir results in uniform flow and recovery of the dielectric fluid through appliance slots, leading to uniform cooling and the absence of operationally obstructive "hot spots")."[382] However, as discussed in this report, the use of a plenum at the bottom of an immersion cooling tank to produce substantially uniformly upward flow through appliance slots followed by a weir that facilitates substantially uniform recovery was known and practiced prior to MGT's purported invention. In addition to the use of a plenum, the use of weirs at the top of the tank were also well know, as discussed in this report. Finally, the prior art discloses systems that would result in an "absence of operationally obstructive 'hot spots.'"[383]

397. For example, the Best References, which each disclose a plenum, appliance slots, and weir, would also exhibit a flow pattern to promote the elimination of "operationally obstructive 'hot spots'." Specifically, Best '463 identifies the existence fluid contained below the appliance slots and a liquid layer of dielectric fluid above the appliance slots which enhances circulation and cooling of through the appliance slots. Best '463 states:

> The mounting members may also be configured to mount the servers such that the top level 460 of liquid coolant completely submerges the top level 472 of the server rack 470 formed by the multiple servers 120. As a consequence, a volume of liquid coolant collects in a common manifold area above the server rack 470 to improve the circulation of the liquid coolant through the plurality of servers, thereby enhancing the cooling of each respective server. The mounting members may also 226 be configured to mount the servers in server rack 470 above the bottom of the tank to create a volume of liquid coolant between each respective server and the bottom of the tank such that the flow of the dielectric liquid coolant through the servers is improved. Preferably, the mounting members are configured to mount the servers closely adjacent to one another in the server rack to restrict the flow of the dielectric liquid coolant between the vertically-oriented servers, such that the flow of the dielectric liquid coolant through the servers is enhanced.[384]

398. As such, immersion systems existed well before MGT's purported invention designed to enhance the flow patterns of the dielectric fluid within the tank in order to promote the elimination of "operationally obstructive 'hot spots.'"

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[380] *Id.* at 6.
[381] *See supra* Background of Technology, Immersion Cooling.
[382] Pl.'s Supp. Resp. to Defs.' Interrog. No. 14 , Mar. 13, 2023 at 6-7.
[383] *See supra* Summary of Prior Art.
[384] Best '463, 14:58-15:8.

399. Therefore, there is no readily apparent reason why MGT's systems offer any meaningful competitive edge over the prior art, much less one that is attributable to the purported inventions claimed in the Asserted Claims of the Asserted Patents.

400. Thus, MGT has not demonstrated a nexus between the commercial success and the alleged invention.

Failure of Others

401. MGT has alleged that the failure of others prior to the purported invention is evidence of non-obviousness. MGT states the following:

> Midas designed and built the very first commercial liquid immersion data center in the world, eventually incorporating the patented technologies, succeeding where others failed at making liquid immersion cooling commercially viable. Failure by others will be shown at least by: (1) The failures and undesirable operation of the GRC Gen1 tank and its associated cooling system. (2) The undesirable failures and operation of air-cooled enterprise systems and Bitcoin miner system.[385]

402. In my opinion, MGT's response is contradicted by information discussed elsewhere in this report showing that, at a minimum, GRC created "commercial liquid immersion data centers" before MGT. For example, in 2010 well recognized scholar and inventor in the field of immersion cooling, Phil Tuma, authored multiple articles discussing the use of immersion cooling in data centers.[386]

403. Further, in 2011, GRC, who is the assignee of the Best References, implemented its CarnotJet immersion cooling systems at a data center for the Texas Advanced Computing Center in Austin, Texas.[387] In addition, in 2011, Intel utilized GRC's CarnotJet system in its data centers.[388] Moreover, GRC has apparently continued to enjoy commercial success for its immersion cooling systems, through its relationship with Intel which continues today.[389] In fact, MGT utilized GRC's CarnotJet immersion cooling system (the Best Tank) in its data center prior

[385] Pl.'s Supp. Resp. to Defs.' Interrog. No. 14, Mar. 13, 2023 at 8.
[386] *See generally*, P. E. Tuma, The merits of open bath immersion cooling of datacom equipment, 2010 26th Annual IEEE Semiconductor Thermal Measurement and Management Symposium (SEMI-THERM), Santa Clara, CA, USA, 2010, pp. 123-131; Phil Tuma, Open Bath Immersion Cooling In Data Centers: A New Twist On An Old Idea, Electronic Cooling (Volume 16, Number 4) Winter 2010, pp. 10-13, http://s3.electronics-cooling.com/issues/ECM_December2010.pdf.
[387] *See* DataCenter Knowledge, Submerged Servers: Green Revolution Cooling, RHOD0001067; DataCenter Knowledge, Green Revolution's Immersion Cooling in Action, RHOD0000880.
[388] *See* Intel does math on oil-dunk test for cooler servers, RHOD0001059.
[389] *See* Intel, White Paper: The Sustainable Data Center Transformation: Reducing Carbon Footprint with Liquid Immersion Cooling, p. 8.

to development of MGT's purported invention.[390] Therefore, it appears that others, including GRC, were ahead of MGT in building a data center utilizing immersion cooling.

404. Likewise, MGT's admits that the "patented technologies" were only "eventually" added to MGT's data centers. Nothing in this response or the sources cited therein show that MGT succeeded where other have failed.[391]

405. Therefore, it is my opinion that there is no nexus between others' purported failures and the claimed invention.

Long-Felt Need

406. MGT has alleged that the long-felt need for the purported invention is evidence of non-obviousness. MGT identifies the following purported long-felt need: "The need for a commercially viable alternative cooling method to the traditional air-cooling available in data centers has been long recognized in the industry but was not accomplished until immersion cooling entered the market. Midas' patented innovations are a leading solution to an existing problem."[392]

407. In my opinion, MGT has not shown that its products satisfy a long-felt need in the market. Indeed, MGT claims it had itself met such a need as early as 2011. Others, including GRC, have offered products that satisfy the need for immersion cooling for data centers prior to 2011. And MGT's own predecessor, Midas Networks, recognized as much when it purchased GRC's systems.

408. For example, Best '463 (which was assigned to GRC and incorporated into its products) presents the problems with cooling in data centers, including cost,[393] ultimately identifying the need for its invention by stating: "[t]herefore, there exists the need for an effective, efficient and low-cost cooling alternative for cooling [] electronic components, such as, for example, rack-mounted servers."[394] Therefore, to the extent a long felt but unsatisfied need existed, Best '463 was directed towards a solution.

409. Thus, it is my opinion that there is no nexus between a long-felt need for the alleged invention.

410. Accordingly, it is my opinion that MGT's purported secondary considerations of non-obviousness do not refute my above analysis on obviousness.

WRITTEN DESCRIPTION AND ENABLEMENT

411. I have not been asked to provide an opinion on the ultimate question of whether the Asserted Claims of the Asserted Patents are invalid for failure to provide an adequate written

[390] *See* CarnotJet™ Four-Rack Installation, GRC0105; Best Decl. ¶¶ 10-11.
[391] Pl.'s Supp. Resp. to Defs.' Interrog. No. 14, Mar. 13, 2023 at 8.
[392] *Id*.
[393] Best '463 at 1:30-4:27.
[394] *Id.* at 4:25-27.

description or for lack of enablement. I have been asked to provide opinions about the patents' disclosures that are relevant to these determinations.

412. It is my opinion that the Asserted Patents do not describe or show (1) "a weir. . .adapted to facilitate substantially uniform recovery of dielectric fluid" or (2) "a plenum. . .adapted to dispense dielectric fluid substantially uniformly upwardly through each appliance slot."

413. Although the specification of the Asserted Patents mentions a plenum and shows a base and a perforated plate atop the plenum, it nowhere addresses the height of the plenum. As depicted in Figure 1, the plenum is much too narrow (that is, too low in relation to the scale of tank). A POSA would know that the point of a plenum is to allow uniform flow and that a plenum would have to have a certain height to achieve the slowing of velocity (settling) that is a prerequisite to uniform flow. (It is referred to as a settling chamber because it must allow fluid to settle and distribute itself so that uniform flow becomes possible.) But a POSA would have to do considerable additional work and experimentation to determine the correct height for the plenum given the other dimensions of the tank. This is not a trivial problem. Additionally, the perforation pattern of the plate does not assure that flow will be uniform. In fact, the pattern of holes shown in the "orifice plate portion of the plenum facility" as shown in the Asserted Patents (in Figures 1, 7 and 8) would not result in substantially uniform upward flow of the dielectric fluid through each appliance slot, or across the bottom of the tank. (I understand that one of the named inventors, Christopher Boyd, acknowledged that equally sized holes would not achieve substantially uniform upward flow through each appliance slot, and I agree.)[395] Thus, the plenum as depicted would not achieve the purposes of a plenum, nor would it achieve the goal recited by the claims, namely, substantially uniform upward flow through each appliance slot. The Asserted Patents do not teach how to size or arrange the holes in the orifice plate to achieve substantially uniform upward flow through each appliance slot, and that is something a POSA would not have known how to achieve in the system disclosed in the patents without considerable additional work and experimentation.

414. The component identified as a plenum in the Asserted Patents is more nearly a manifold, which is a component that takes the flow of fluid from a central location and distributes it to many other locations (here, orifices). Manifolds present similar design issues to plenums; in particular, the challenges to achieve uniform flow are similar. The diameter of the holes must be exactly right; they cannot be arbitrarily chosen. A pressure drop occurs as a function of the orifices. To achieve uniformity of flow, the pressure drop must be just high enough to cause flow to find path of least resistance that spreads out uniformly. If the holes are too large and the pressure drop is consequently too small, the flow will be maldistributed and be non-uniform. In the "plenum" shown in the Asserted Patents, the result of oversized perforations would be more flow near the middle and less flow near the ends of the plate. If the holes are too small, the pressure different above and below the perforated plate would be too high, which would require excessive pressure in the plenum.

415. Based on the limited description given to the details of the outflow weir as disclosed in the Asserted Patents, *see* **22** in Figures 5 and 6 of the '457 patent, the weir would not facilitate uniform recovery of the dielectric fluid because the level of the surface of the fluid, which is established by the vertical position of the weir, appears to coincide with the top of the electrical

[395] Boyd Dep. 255:8-256:13, Dec. 7, 2023.

appliances. There is no volume above the electrical appliances for the fluid to mix and become uniform in velocity and temperature. In contrast to Best '463, which specifies that the surface level should be above the top of the appliances thus creating a weir above the appliances, the Asserted Patents make no such allowances.

416. In the Asserted Patents, the weir and plenum are not described in such a way that a POSA could implement them without undue experimentation. Therefore, it is my opinion that a POSA reading the Asserted Patents at the purported date of invention would not have known how to achieve the claimed invention or understood that the applicants were in possession of the claimed subject matter.

LIST OF ATTACHMENTS AND EXHIBITS

Exhibit A – List of Information Considered
Exhibit B – Curriculum Vitae
Exhibit C – List of Prior Testimony
Exhibit D-1 – Claim Chart based on Best '463 over '457 Patent.
Exhibit D-2 – Claim Chart based on Best Publication over '457 Patent.
Exhibit D-3 – Claim Chart based on Best Tank over '457 Patent.
Exhibit D-4 – Claim Chart based on Oktay '244 over '457 Patent.
Exhibit D-5 – Claim Chart based on JP '758 over '457 Patent.
Exhibit D-6 – Claim Chart based on Pfanhl Application over '457 Patent.
Exhibit D-7 – Claim Chart based on Krajewski '511 over '457 Patent.
Exhibit D-8 – Claim Chart based on Gryzhin '013 over '457 Patent.
Exhibit D-9 – Claim Chart based on Best '914 over '457 Patent.
Exhibit E-1 – Claim Chart based on Best '463 over '446 Patent.
Exhibit E-2 – Claim Chart based on Best Publication over '446 Patent.
Exhibit E-3 – Claim Chart based on Best Tank over '446 Patent.
Exhibit E-4 – Claim Chart based on Oktay '244 over '446 Patent.
Exhibit E-5 – Claim Chart based on JP '758 over '446 Patent.
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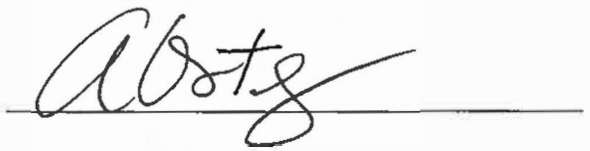
Exhibit E-7 – Claim Chart based on Krajewski '511 over '446 Patent.
Exhibit E-8 – Claim Chart based on Gryzhin '013 over '446 Patent.
Exhibit E-9 – Claim Chart based on Best '914 over '446 Patent.

RESERVATION OF RIGHTS

I may address other issues in later expert reports as needed to address additional discovery, additional reports offered by MGT's, and/or additional guidance from the Court. I may also enlarge, animate, color or otherwise adapt portions of the above-cited documents to illustrate my above opinions.

Executed this 22nd day of December 2023.



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